HYDROGEOLOGIC ANALYSIS FOR THE EXISTING SANITARY LANDFILL

Prepared For

UNIFIED DISPOSAL DISTRICT
Havre, Montana

OCTOBER, 1991

MONTANA DEPARTMENT OF HEALTH
AND ENVIRONMENTAL SCIENCES
Solid & Hazardous Waste Bureau
836 Front Street
Helena, MT 59620
Rec'd 10/30/91

Prepared By

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October 29, 1991

Mr. Ralph Smith
Montana Department of Health &
Environmental Sciences
Solid and Hazardous Waste Bureau
Cogswell Building
Helena, MT 59620

RECEIVED
JAN 17 1992
MONTANA DEPARTMENT OF HEALTH
AND ENVIRONMENTAL SCIENCES
SOLID AND HAZARDOUS WASTE BUREAU

Dear Ralph:

Please find enclosed two (2) copies of a hydrogeologic report that our firm has prepared for the Unified Disposal District's landfill located approximately 10 miles east of Havre. We have already submitted to you a copy of our landfill design and sequence plan for the effective operation of the site.

If you have any questions or comments on either the hydrogeologic report or the landfill plans, please contact us at your earliest convenience. We look forward to receiving any comments that you may have.

Very truly yours,

DAMSCHEN & ASSOCIATES, INC.

Barry E. Damschen, P.E.
Project Manager

Enclosure

REPORT OF MONITORING WELL INSTALLATION AND HYDROGEOLOGIC INVESTIGATION

PREPARED FOR

UNIFIED DISPOSAL DISTRICT LANDFILL
HAVRE, MONTANA

SEPTEMBER, 1991

MONTANA DEPARTMENT OF HEALTH
AND ENVIRONMENTAL SCIENCES
Solid & Hazardous Waste Bureau
836 Front Street
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October 16, 1991

Unified Disposal Board
Hill County Courthouse
Havre, Montana

Subject: Report of Monitoring Well Installation and Hydrogeologic Investigation Unified Disposal District Landfill East of Havre, Montana

Dear Board Members:

We are pleased to submit this Report of Monitoring Well Installation and Hydrogeologic Investigation for the existing and proposed expansion of the landfill east of Havre.

The following report provides a description of the investigations performed and our conclusions and recommendations regarding the hydrogeologic aspects and design of the landfill at the site. Also included is information regarding ground water quality at the site.

We appreciate the opportunity to serve the Unified Disposal District on this project and trust this report meets your current needs. If you have any questions or need additional information or assistance please contact us.

Very truly yours,

DAMSCHEN & ASSOCIATES, INC.

Barry E. Damschen, P.E.
Project Manager

Enclosures

DANSCHEN & ASSOCIATES, INC.
Consulting Engineers

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REPORT OF MONITORING WELL INSTALLATION AND HYDROGEOLOGIC INVESTIGATION

UNIFIED DISPOSAL DISTRICT LANDFILL EAST OF HAVRE, MONTANA

I. INTRODUCTION

This report presents the results of monitoring well installation and a hydrogeologic investigation for the Unified Disposal District landfill located south of U.S. Highway 2 midway between Havre and Chinook in Blaine County, Montana. A vicinity map illustrating the location of the site is presented on Plate 1.

A. Purpose and Scope of Work

The purpose of this report is to document the existing site hydrogeologic conditions, record the details of monitoring well installation, evaluate the feasibility of the proposed landfill expansion area with respect to the site conditions and provide recommendations regarding the design of the proposed landfill expansion area. This report also addresses the presence of a seepage area adjacent to the existing landfill area. This seepage was investigated and mitigation measures for controlling the seepage were evaluated and recommended.

The scope of work included research of available information, excavation of test pits, drilling of test borings, collection and

analysis of ground water samples, and compilation of this report.

B. Site Description

The site is located approximately 11 miles east of Havre, Montana. The area is located in and around a coulee which initiates within the existing landfill and terminates near the Milk River. The site has a total of 250 acres in Section 1 of Township 32 North, Range 17 East and Section 6, T 32 N, R 18 E. A site plan is presented on Plate 2. Approximately 25 acres are currently being used for the existing landfill and 40 acres are included in the proposed landfill expansion area. The remaining acreage includes the shop and container site, roads, and unused land. The elevation of the site is approximately 2600 feet above mean sea level.

The existing landfill area is located in the central part of the site (see Plate 2). The depth of fill is as much as twenty to thirty feet in the bottom of the coulee. According to the landfill operation plan prepared by Damschen & Associates, this area will be filled to a maximum additional depth of 60 feet prior to closure.

The proposed expansion area is located on the north side of the site. This area is relatively level and has been previously used for farming (see Plate 2).

analysis of ground water samples, and completion of this report.

B. Site Description

The site is located approximately 11 miles east of Havre, Montana. The area is located in and around a coulie which intersects within the existing landfill and terminates near the Milk River. The site has a total of 152 acres in Section 1 of Township 32 North, Range 17 East and Section 6, T 32 N, R 18 E. A site plan is presented on Plate 2. Approximately 25 acres are currently being used for the existing landfill and 40 acres are included in the proposed landfill expansion area. The remaining acreage includes the shop and container site, roads, and unused land. The elevation of the site is approximately 2650 feet above mean sea level.

The existing landfill area is located in the central part of the site (see Plate 2). The depth of fill is as much as twenty to thirty feet in the bottom of the coulee. According to the landfill operation plan prepared by Dasconch & Associates, this area will be filled to a maximum additional depth of 60 feet prior to closure.

The proposed expansion area is located on the north side of the site. This area is relatively level and has been previously used for farming (see Plate 2).

The south side of the site is not planned for landfilling and has previously been farmed. The south area contains two small gravel pits (see Plate 2).

II. INVESTIGATIONS

The investigations for this analysis consisted of records research, backhoe test pits, drilled test borings, installation of monitoring wells, monitoring of ground water levels, and ground water sampling and testing. It should be noted that much of this investigation was conducted during the summer and fall of 1989, a period in which the Havre area received unusually high amounts of precipitation. The shallow soil moisture conditions encountered may have correspondingly been abnormally high.

A. Records Research

As a part of this investigation, we researched several sources of published and unpublished information. The types of information researched included logs of water wells, published geologic mapping, published soil mapping, and previous investigations conducted at the site.

1. WATER WELL LOGS

Initially a computer summary of water well logs on file with the Montana Bureau of Mines and Geology (MBMG) for a 144 square mile area surrounding the site was obtained. This summary is

presented in Appendix A. In all, the summary listed 115 wells in the area. Additionally, copies of logs for the existing wells on the site and for some of the wells nearest the site were also obtained. Copies of these well logs are presented in Appendices B and C. Additional information was obtained from Levings (1981).

2. PUBLISHED GEOLOGIC INFORMATION

Only generalized geologic and structural maps of the area are available, along with generalized descriptions of regional aquifers. A listing of the published information located is presented in the References section at the end of this report.

3. PREVIOUS INVESTIGATIONS

An investigation of the site was conducted in 1983 by Havre Testing Labs as a part of siting the landfill. A copy of the letter report dated May 18, 1983 is attached in Appendix D.

Test borings were also completed in 1983 as part of siting the landfill. One boring was drilled and completed as a production well at the shop and a second boring was drilled and completed as a dry observation well near the landfill area. Locations of these wells are presented on Plate 2. Logs of these borings are presented in Appendix B.

B. Test Pits

A total of 33 test pits were excavated to a maximum depth of twenty feet in July and August, 1989. The approximate location of the test pits are shown on Plate 2. The test pits were field logged by Damschen & Associates personnel. The logs of test pits are presented in Appendix E.

The test pits were backfilled after perforated pipe was placed in the excavations. Water levels in the test pits were measured periodically by the landfill operators during the summer and fall of 1989. Damschen and Associates personnel measured the depths to water in the test pits on September 1, 1989. These depths were correlated to surveyed test pit elevations to obtain water level elevations. Using these elevations and estimated elevations of active seepage from the cut slope on the south side of the active landfill area, contours of equal elevation of the water table in the area south of the existing landfill were plotted. The water table elevation at the wells and the plotted contours are included on Plate 2. The approximate northern limit of the shallow ground water is also delineated on Plate 2.

C. Drilled Test Borings

A total of five (5) test borings were drilled south and north of the existing landfill area. The approximate locations of the borings are also depicted on Plate 2. The borings were drilled to a maximum depth of 254 feet and samples of cuttings were taken

B. Test Pits

A total of 33 test pits were excavated to a maximum depth of twenty feet in July and August, 1989. The approximate location of the test pits are shown on Plate 2. The test pits were field logged by Ceasedon & Associates personnel. The logs of test pits are presented in Appendix B.

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C. Drilled Test Borings

A total of five (5) test borings were drilled south and north of the existing landfill area. The approximate locations of the borings are also depicted on Plate 2. The borings were drilled to a maximum depth of 75ft feet and samples of cuttings were taken

at selected intervals during drilling. Test borings TB-1, TB-2, and TB-3 were drilled on October 23, 1989, with a Failing Holemaster rotary drill rig using a drag bit and compressed air circulation. The drill rig was provided and operated by Hickel and Tooke Drilling of Turner, Montana. Boring MW-1 was drilled on October 23 and 24 and MW-2 was drilled on October 24, 1989 with the same drill rig.

The test borings were logged by hydrogeologist, Curt Coover, by examining cuttings expelled from the borings during drilling. Descriptions of the materials encountered are presented on the logs of borings in Appendix F. A geologic cross-section through test borings MW-1, TB-3, TB-1, and MW-2 is presented on Plate 3.

At each major sandstone bed encountered during drilling, air circulation was shut off for several minutes to allow any ground water present to seep into the borings. Upon resumption of drilling, any water within the bore holes was circulated up the holes and water which was expelled from the top of the borings was considered detectable ground water and was noted on the logs.

D. Monitoring Well Installation

Borings MW-1 and MW-2 were completed as monitoring wells. The wells were completed using 2-inch diameter flush-threaded polyvinyl chloride (PVC) well casing with factory-slotted PVC screen. Silica sand was used as gravel pack and bentonite grout and Portland cement were used to seal the annular space.

Aluminum well covers were installed at the surface to protect the PVC and to provide security. The details of well completion are presented in Appendix G.

Borings TB-1, TB-2, and TB-3 were left open for three days to monitor ground water levels; then were grouted using a Portland cement slurry.

E. Water Quality Sampling

On January 23, 1990, samples of water were collected from the standpipes in test pits 5, 16, and 27, the existing observation well, and the shop well. The locations of these wells are presented on Plate 2. All samples were field tested for pH, temperature, and specific conductivity. The samples from TP-16, TP-27, and the observation well were packaged and sent to Energy Laboratories for analysis of several indicator parameters including total dissolved solids, specific conductance, pH, total ackalinity, sulfate, chloride, chromium, magnesium and BOD.

The purpose of this water quality sampling was to provide a preliminary evaluation of contamination of the shallow ground water from leachate emanating from the existing landfill. Results of this field and laboratory testing are discussed later in this report. The laboratory reports are presented in Appendix H.

On April 4, 1991, ground water samples were withdrawn from MW-1,

MW-2, and the shop well. These samples were sent to Energy Laboratories in Billings for analysis of a suite of parameters which are listed in the proposed RCRA Subtitle D landfill regulations. The purpose of the second ground water sampling was to evaluate contamination from leachate in the bedrock aquifer and to provide baseline data for the new monitoring wells and the existing shop well. The laboratory reports are presented in Appendix I.

III. FINDINGS

As previously indicated, this investigation was conducted to evaluate the hydrogeologic conditions in the proposed landfill expansion area and for the existing landfill seepage area. Some of the findings are pertinent to only one or both of the areas and are presented herein topically without specifically addressing each area. Each area is discussed specifically within the Conclusions and Recommendations section of this report.

A. Records Research

1. PUBLISHED SOIL MAPPING

According to published soil information provided by the Soil Conservation Service (SCS) office in Havre (Hilts, 1986), three soil units underlie the landfill site.

Uplands in the proposed expansion area, the area south of the

existing waste area, and the unused northwest corner of the site are underlain by clay loam to loam of the Williams-Vida soil series. According to the Soil Survey, these soils are derived from glacial deposits and have moderately slow permeability, a slight potential for erosion, and are susceptible to piping. According to the SCS report, these soils are classified as having a moderate limitation to trench-type landfilling and are rated as fair for use as daily cover because of the high clay content.

A gravel pit within this soil unit is located approximately one mile west of the site. A larger gravel pit surrounded by this soil unit is located approximately 1½ miles northeast of the site. The larger gravel pit is mapped as sand and gravel of the Attewan-Wabek soil complex, which is derived from glacial deposits. These soils have a moderate to very rapid permeability and are good sources of engineered gravel fill. According to the SCS report, these soils have a severe limitation to trench landfilling because of the high permeability, but are fair for use as daily cover because of the lack of silt and clay. The smaller gravel pit west of the site and the gravel underlying the south portion of this site probably belong to this soil complex.

The saddle east of the existing landfill area is mapped as clay loam of the Bearpaw-Elloam soil series. According to the soil survey, these soils are also derived from glacial deposits and have slow to very slow permeability and a moderate potential for erosion. These soils are classified as having a moderate limitation to trench-type landfilling according to the SCS report

and are rated as fair for use as daily cover because of the high clay content.

The coulee area and sloped areas along the north side of the site are mapped as loam of the Cabra-Zahill soil series. These soils are derived from the underlying shale and sandstone bedrock and have moderate permeability and a severe potential for erosion. According to the SCS report, these soils are classified as having a severe limitation to trench-type landfilling and are rated as poor for use as daily cover because of the steep slopes and shallow depth to bedrock.

2. PUBLISHED GEOLOGIC MAPPING

A generalized geologic map of the region (Ross, et al., 1955) indicates that the bedrock in the area includes sandstone, shale and minor amounts of coal in the Cretaceous-aged (65 to 135 million years old) Judith River Formation. The Judith River formation is a fluvial deposit which includes erosional channels filled with sand (Noble, et al., 1982). The bedding in the area is relatively flat-lying with a regional dip to the northeast, away from the Bearpaw Mountains.

Structural mapping in the area (Stebinger, 1916) indicates that a pair of anticlines are located approximately 3 miles west of the site in the Little Boxelder Creek area. If the structures were continuous to the southwest, the axial trace of the northern anticline would pass more than a mile south of the site.

Numerous other structures were mapped in the area, which indicates that the mapping was fairly detailed, however no structures were mapped at the site. Based on this information, it may be assumed that the bedding dips to the northeast if no other structural deformities exist between the Little Boxelder anticlines and the site. This agrees with the attitude of outcrop exposures at the site.

3. REGIONAL HYDROGEOLOGY

In general, three aquifers are present at relatively shallow depths near the site (Noble, et al., 1982). The Milk River alluvium aquifer is present only in the valley-bottom along the river north of the site. Other minor alluvial aquifers may be present adjacent to smaller creeks in the area. An aquifer is present in places within the glacial drift, especially where sand and gravel deposits occur. Both the alluvial and drift aquifers are discontinuous in occurrence. A third aquifer is present within the bedrock in the area. Ground water is produced from various sandstone beds within the Judith River formation. This aquifer is generally continuous in the area near the site.

Based on the available well log information, numerous wells produce from the alluvial aquifer along the Milk River. Several scattered wells produce from sandstone beds within the Judith River aquifer. The computer well summary was not sufficiently detailed to identify wells completed in the drift aquifer.

The approximate locations and elevations of some wells that likely tap the Judith River aquifer were plotted on a topographic map. Based on these estimated elevations, the static water elevations were obtained by using data from the driller's logs. Contours of equal elevation of the static water level in the wells were plotted. Few usable data points were present north of the river and, therefore, contours plotted in the area are approximate. Additional data points north of the map area were used to plot these contours. The resulting contour map shows the potentiometric surface of the Judith River aquifer, and is presented on Plate 1. The contours on this ground water map indicate a definite northward direction of flow in the area south of the river beneath the landfill site. The few data points available north of the river suggest an easterly direction of flow along the river and a southeasterly direction of flow in the area north of the river.

The elevation of the potentiometric surface in the Judith River aquifer along the river area is essentially the same as the river water surface elevation. These elevations also correlate well with water table elevations in the Milk River alluvium aquifer. The water table elevations were obtained using the same methods as for the wells in the Judith River aquifer, but were omitted from the map for clarity.

4. PREVIOUS INVESTIGATIONS

The investigation conducted by Havre Testing Labs included 5 test pits to a maximum depth of 12 feet. Three pits were excavated in the bottom of the coulee and one pit each were excavated in the north and south sides of the site above the coulee. Silty clay loam was encountered in all of the pits. The soils were described as "dry" except in the current fill area where "moist" soil was described.

The report noted "some localized seepage" from the south side of the coulee, but attributed it to a heavy rainstorm three days prior to the investigation. This is apparently the same seepage area which is addressed by this report.

Two test borings were drilled at the site in 1983 by Hi-Line Drilling of Havre. At the shop site, the boring encountered colluvial soils including clay with one thin minor gravel bed to 26 feet. Shale and sandstone were then encountered to the total depth drilled of 138½ feet. Ground water was reported to occur in sandstone at a depth of 76 to 86 feet at a maximum yield of two gallons per minute (gpm). This boring was completed as a production well and is used at the shop.

The second test boring was drilled in the bottom of the coulee near the landfill area. This boring encountered sandy colluvium to the total depth drilled of 50 feet. No ground water was encountered. This boring was completed as an observation well at

a depth of 30 to 50 feet. It had been dry since it was drilled in 1983 and water was detected in the well for the first time in 1989.

Seepage of water from a cut along the south side of the existing landfill was first noticed by the operators in 1988. The rate of seepage was not measured, but may be on the order of 5 to 20 gallons per hour. Also, a shallow gravel pit on the south side of the site excavated in 1988 contains standing water.

B. Field Investigation

1. TEST PITS

a. North Side Expansion Area

Generally, the test pits which were excavated on the north side of the site in the proposed expansion area encountered sandy to clayey silt to the maximum depth excavated of 19 feet. The silt deposits belong to the glacial drift. A thin layer of gravel was encountered in TP-23 at a depth of two to four feet. The average depth of excavation for the trenches in this area is 20 feet and the gravel lens will be excavated during development. Shale bedrock was encountered in test pits TP-23, TP-25, and TP-26 at depths as shallow as four feet.

b. Central Existing Landfill Area

Four test pits were excavated in the coulee near the landfilled area (see Plate 2). No test pits were excavated within the

filled area.

Colluvial soils including mixtures of silt, sand, clay, and rock fragments of various sizes were encountered to the maximum depth explored in the bottom of the coulee while colluvial soils underlain by shale bedrock were encountered on the side slopes of the coulee.

c. South Side

The test pits which were excavated on the south side of the site south of the active landfill area encountered a variety of materials. Several test pits encountered a sand and gravel deposit within the glacial drift south of the fill area. The gravel was encountered just below a thin layer of top soil and extended to various depths generally ranging from five to ten feet. TP-5 and TP-7 were excavated within existing small gravel pits and the maximum depth of the sand and gravel deposit was 15 feet below natural grade. TP-3 encountered sand and gravel extending below the maximum depth explored of 19½ feet. The approximate extent of this sand and gravel deposit is delineated on Plate 2.

A sand deposit was encountered near the southwest corner of the site. This sand deposit within the glacial drift contained interbeds of clay with minor gravel lenses. The sand generally extended to a depth of five to ten feet. The approximate extent of this sand deposit is delineated on Plate 2.

Thin coal beds were encountered in several test pits along the south property line. The approximate areal extent of the coal beds within the site is delineated on Plate 2.

2. TEST BORINGS

All of the test borings encountered glacial drift to a maximum depth of 16 feet. The drift was similar to the drift encountered in the test pits. Interbeds of gray to brown shale and gray sandstone were drilled below the drift to the maximum depth of 254 feet. A few hard layers and shell beds were encountered and a coal bed was encountered near the surface in MW-2.

Based on topographic and aerial photographic lineations, the bedding in the area appears to strike at approximately north 75 degrees west . The dip of the bedding measured in the field ranges from level to three degrees to the northeast. Based on the assumed strike and the range of dips measured, we could trace bedding only over short distances, and reliable correlations between borings on the geologic cross-section on Plate 3 were not possible. Folding or faulting of the bedding is not consistent with the regional geologic setting and, therefore, it appears that bedding at this site is lenticular and discontinuous in nature.

C. Site Hydrogeology

1. SHALLOW GROUND WATER

Shallow ground water conditions were evaluated primarily using the test pit information with additional information obtained from the test borings.

No ground water was encountered in any of the pits which were excavated in the north side expansion area. Boring MW-1 was left open overnight at a depth of 42 feet and no water was detected. Boring TB-3 was dry for one day and produced a trace of water over three days from 80 feet of open hole. No seeps, springs, or excessively wet areas were noted to exist on or near the ground surface on the north side of the site.

Ground water was detected in most of the test pits on the south side of the site, but was concentrated in the area south of the existing landfilling area. The source of seepage into the pits included coal-bearing strata and sand and gravel beds, but minor occurrences of water in shale were also observed. The rate of seepage into the test pits was very slow, mostly on the order of gallons per hour.

Based on the water table contours presented on Plate 2, the direction of ground-water flow within the shallow water-bearing zone is northward. Highly vegetated areas, which indicate wet areas probably fed by seepage, were noted in the minor coulee

E. Site Hydrogeology

1. Shallow Ground Water

Shallow ground water conditions were evaluated primarily using the test pit information with additional information obtained from the test borings.

No ground water was encountered in any of the pits which were excavated in the north side expansion area. Boring MW-1 was left open overnight at a depth of 42 feet and no water was detected. Boring TB-3 was dry for one day and produced a trace of water over those days from 60 feet of open hole. No seeps, springs, or respectively wet areas were noted to exist on or near the ground surface on the north side of the site.

Ground water was detected in most of the test pits on the south side of the site, but was concentrated in the area south of the existing landfilling area. The source of seepage into the pits included coal-bearing strata and sand and gravel beds, but minor occurrences of water in shale were also observed. The rate of seepage into the test pits was very slow, mostly on the order of gallons per hour.

Based on the water table contours presented on Plate 3, the direction of ground-water flow within the shallow water-bearing zone is northward. Highly vegetated areas, which indicate wet areas, probably fed by seepage, were noted in the minor coulee

south of the existing landfill on aerial photos taken in June of 1987. The locations of these seepage areas, along with the seepage observed from the cut slope along the south side of the active landfill area are presented on Plate 2. These seepage areas correspond well with the expected surface exposure of the water table map constructed from the test pit information. This indicates that the seepage is a direct result of discharge from the shallow ground water system on the south side of the site. The source of the shallow ground water is probably direct infiltration of precipitation from the cropland south of the site.

In the southwest corner of the site, seepage at the coulee was not observed and the fate of the shallow ground water in that area is unclear. Since this area is not proposed to be landfilled under the design, significant investigations in this area were not conducted.

Ground water occurrence within the existing landfill area was not evaluated during this investigation. Seepage of water into the landfill area was observed along the south rim of the coulee, as noted above. Ground water was also detected in test pit 27, west of the filled area in the bottom of the coulee.

2. DEEP GROUND WATER

a. Occurrence

Although shallow ground water is present in portions of the site, ground water was not detected while drilling in bedrock at test borings TB-1, TB-2, and TB-3. However, minor amounts of water seeped into the borings during the three days that they were left open.

Test boring TB-1 contained a trace of water following drilling and the water rose to 55 feet in three days. Shallow ground water within the near-surface gravel is evident in the excavation adjacent to TB-1 and 18 feet of casing was set to seal off any seepage from the gravel. It is possible that the water in the boring seeped behind the casing from this gravel. However, it is also possible that the water originated in a sandstone layer at 52 to 60 feet.

Approximately 1½ gallons per minute of water was produced from the near-surface sand in TB-2. Steel casing was set to 19 feet to seal off this water. The boring was dry after drilling, but contained a trace of water after five hours. The water had risen to 70 feet after three days. The source of this water is unclear. Water could have seeped behind the casing from the sand or may have seeped from sandstones at 33 to 41 feet or 59 to 60 feet. A total of approximately seven gallons of water accumulated in the boring over three days, which is such a small amount that the determination of the source cannot be clearly

made.

Ground water was not detectable during drilling in boring TB-3 and the boring remained dry for more than a day. After three days, a trace of water had seeped into the boring. No casing was set in this boring and a possible source of the seepage was a sandstone lense encountered at 68½ to 70 feet.

Ground water was first detected in boring MW-1 at a depth of 238 feet. The yield of this water-bearing zone was estimated to be 10 gpm. This boring was completed as a monitoring well in this water-bearing zone.

A shallow ground water zone that produced less than 1 gpm was detected in MW-2 at 11 feet, but was sealed off with steel casing. The first detectable water below the casing was encountered at 229 feet. This water-bearing zone was estimated to produce approximately 3 gpm. This boring was completed as a monitoring well in this water-bearing zone.

b. Static Water Levels and Direction of Flow

The water levels in monitoring wells MW-1 and MW-2 were measured on January 23 and the shop well was measured on January 30, 1990. The levels were measured again on November 9, 1990. These depths generally correspond with the other producing wells in the area.

The elevations of the water-bearing zones encountered in the two monitoring wells, the shop well and the nearest well to the north

zone.

Ground water was not detectable during drilling in boring TS-3 and the boring remained dry for more than a day. After three days, a trace of water had seeped into the boring. No casing was set in this boring and a possible source of the seepage was sandstone lenses encountered at 68% to 74 feet.

Ground water was first detected in boring MW-1 at a depth of 31½ feet. The yield of this water-bearing zone was estimated to be 1½ gpm. This boring was completed as a monitoring well in this water-bearing zone.

A ability ground water zone that produced less than 1 gpm was detected in MW-2 at 11 feet, but was sealed off with grout casing. The first detectable water below the casing was encountered at 217 feet. This water-bearing zone was estimated to produce approximately 3 gpm. This boring was completed as a monitoring well in this water-bearing zone.

b. Static Water Levels and Direction of Flow

The water levels in monitoring wells MW-1 and MW-2 were measured on February 21 and the shop well was measured on January 26, 1990. The levels were measured again on November 9, 1990. These depths generally correspond with the other producing wells in the area.

The elevations of the water-bearing zones encountered in the two monitoring wells, the shop well and the nearest well to the north

were estimated. These elevations, as well as the reported yields, thicknesses, static water levels, and hydraulic heads of the water-bearing zones are presented on Table 1.

Table 1

Water-bearing Zones in Wells at and near the Site

Well	Top of Aquifer Elevation (ft)	Aquifer Thickness (ft)	Aquifer Yield (gpm)	Static Water Level (ft)	Aquifer Head (ft)
MW-1	2339	12	10	2442	103
MW-2	2394	5	3	2433	39
Shop Well	2396	10	2	2435	36
1/2 Mile No.	2375	20	20	2434	60

The data presented in Table 1 indicate that the water-bearing zones encountered in the wells are variable in elevation, thickness, yield, and head. Of the four wells, only MW-2 and the shop wells are similar. It appears that these two wells may represent the same water bearing zone, however, this conflicts with the regional northwesterly dip. It is doubtful that any of these wells are completed within the same water-bearing zone. The discontinuity of the water-bearing zones is further discussed in the water quality section of this report.

Considering that the wells on the site are apparently not all completed within the same water-bearing zone, use of the static water levels from these wells will not provide an accurate direction of ground-water flow. The direction of ground-water flow at the site can best be determined using the regional

information presented on Plate 1. This regional direction of ground water movement in the Judith River formation is toward the north in the area near the site.

c. Recharge and Discharge

Recharge to the Judith River aquifer probably occurs where sandstone beds outcrop along stream beds south of the site. Recharge may also occur where shallower glacial drift aquifers overlie sandstone beds. Considering that the water-bearing zones in the wells at the site appear to be discontinuous, the recharge areas for the various water-bearing zones are probably slightly different.

At the site, the shallow ground water within the glacial drift and coal displays a much higher static water elevation than the underlying sandstone aquifers. If ground water movement is occurring between the two aquifers, then this movement must be downward from the drift and coal to the sandstone beds below.

As previously stated, the static water level of wells completed in the Judith River aquifer along the Milk River are very similar to the elevation of the alluvial aquifer water table and the river surface as estimated from published topographic maps. This suggests that the Judith River aquifer may be discharging into the alluvial aquifer and/or the river. Additional discharge occurs through numerous wells along the Milk River valley that tap this aquifer.

d. Aquifer Properties

Transmissivities and hydraulic conductivities of the producing zones in the monitoring wells, the shop well, and a well one-half mile north of the site were estimated using data recorded during this investigations and as reported on driller's logs. Simple correlation methods used for determination were based on the specific capacities of the wells as published in Walton (1987), Driscoll (1986), and Bureau of Reclamation (1981). Results of these estimations are summarized on Table 2.

Table 2
Estimates of Aquifer Properties

Well	Specific Capacity gpm/ft	Transmissivity gpd/ft	Thickness ft	Aquifer Hydraulic Conductivity ft/yr	cm/sec
MW-1	0.10	200	12	810	8x10-4
MW-2	0.08	160	5	1600	2x10-3
Shop Well	0.04	86	10	420	4x10-4
½ Mi. North	0.6	1300	20	3100	3x10-3

e. Leachate and Ground Water Movement

Any leachate that may be generated from the landfill must percolate through the landfill base materials to the aquifer before the ground water can be contaminated. In the proposed expansion area, approximately 165 feet of shale interbedded with 65 feet of sandstone separate the landfill base from the deep aquifer, based on the log of boring MW-1. Time transport of leachate through these materials is estimated based on these thicknesses, estimated average hydraulic conductivity values, and estimated effective porosities. Published hydraulic conductivity

5. Aquifer Properties

Transmissivities and hydraulic conductivities of the producing zones in the monitoring wells, the shop well, and a well one-half mile north of the site were estimated using data recorded during this investigations and as reported on Driller's logs. Simple correlation methods used for determination were based on the specific capacities of the wells as published in Water Supply Bulletin (1958), and Bureau of Reclamation (1981). Results of these estimations are summarized on Table 5.

Table 5

Estimates of Aquifer Properties

Well	Specific Capacity gpm/ft	Transmissivity ft	Aquifer Thickness ft	Hydraulic Conductivity (T/b) GPD/ft
MW-1	0.10	140	15	810
MW-2	0.05	160	5	1600
Shop Well	0.04	54	10	470
1/2 Mi. North	0.5	1300	20	3100

6. Leachate and Ground Water Movement

Any leachate that may be generated from the landfill must percolate through the landfill base materials to the aquifer before the ground water can be contaminated. In the proposed expansion area, approximately 165 feet of shale interbedded with 55 feet of sandstone separate the landfill base from the deep aquifer, based on the log of boring MW-1. Time transport of leachate through these materials is estimated based on these thicknesses, estimated average hydraulic conductivity values, and estimated effective porosities. Published hydraulic conductivity

values of shales and siltstones range from 10^{-7} to 10^{-12} cm/sec (Davis, 1969; Bureau of Reclamation, 1981; Driscoll, 1986; Walton, 1989). A conservative estimate based on these ranges is 10^{-7} cm/sec for use in calculations. The value is reasonable based on our experience with other shales in Montana.

Effective porosity is estimated at one third to one quarter of total porosity for clay based on data from Liao and Daniel (1989). Total porosity is reported to range from 1% to 40% for shales and siltstones. An effective porosity of 10% is used herein for calculations. If there is no head of leachate within the waste layers, a gradient of 1 is used for calculations.

Based on these estimates, the velocity of water through the shale at the site would be near 1×10^{-6} cm/sec or 1 ft/yr if a constant supply of water or leachate were available. Based upon this estimate the time for transport of contaminants through the shale in the northern expansion area would be approximately 165 years.

Published hydraulic conductivity values of sandstones range from 10^{-2} to 10^{-8} cm/sec and data from the aquifers around the site indicate a horizontal hydraulic conductivity of around 10^{-3}. Time for vertical transport through the sandstone is probably short compared to the shales and can be ignored.

The estimate of 165 years is for aqueous leachate based on very broad assumptions. This estimate is based on shale permeability

data from other sites and may be in error by up to an order of magnitude. A more accurate estimate would require site-specific permeability test data. This estimate also assumes that shale beds are laterally continuous which may not be the case.

Different contaminants move at different rates through these materials. Many contaminants are adsorbed by the clay in the shale or are dispersed, resulting in a leachate that is greatly diluted for most contaminants by the time deep-lying aquifers are encountered.

Any leachate emanating from the existing landfill site may percolate downward through the sandstone and shale to the sandstone aquifer. The depth to the sandstone water-bearing zone in this area is probably at least 125 feet below the base of the buried waste. The log of the observation well indicates that the thickness of colluvium in the coulee is at least 50 feet. If the thickness of colluvium under the waste is 50 feet, then approximately 75 feet of bedrock separates the colluvium from the sandstone aquifer. If 50 feet of the bedrock is shale, then the time of travel through the bedrock would be estimated at 50 years. The time of travel through the colluvium cannot be reasonably estimated based on the available information.

Since there is a sharp difference in estimated hydraulic conductivities of the sandstone and the shale, there is a possibility of lateral movement of leachate within the more permeable sandstone beds. This pathway was not evaluated during

this investigation.

Based on ground water occurrence in test pit 27 and the observation well, the uppermost ground water in the active landfill area is likely to occur within the colluvium. Insufficient information has been collected to evaluate ground water conditions in the colluvium. However, it is anticipated that the direction of ground water movement in the colluvium would be down the coulee to the west and north. Ground water in the colluvium may be connected to the Milk River aquifer or may discharge into a sandstone aquifer. Additional investigation is required to properly characterize the ground water conditions in the colluvium.

3. WATER QUALITY

Samples of the shallow ground water upgradient and downgradient from the existing landfill were collected for field and laboratory analysis. Samples were collected from test pits 5 (drift gravel), 16 (drift clay), and 27 (colluvium), the existing observation well (colluvium), and the shop well (sandstone). See Plate 2 for locations of the sampling sites. Other test pits in the shallow ground water area south of the existing landfill were unsuitable for sampling due to crushing of the observation pipes following installation. Field readings of temperature, pH, and specific conductivity were recorded. Three of the samples were laboratory tested for properties including specific conductivity, pH, and biochemical oxygen demand (BOD_5);

and concentrations of total dissolved solids (TDS), total alkalinity, sulfate, chloride, chromium, and manganese. These parameters are considered to be inorganic indicators of solid waste leachate. The results of the testing are summarized in Table 3. The laboratory reports are attached in Appendix H.

Table 3
Analyses of Shallow Ground Water Samples

	Upgradient		Waste Cell Apparently Downgradient		
Field Parameter	TP-5	TP-16	TP-27	Obs. Well	Shop Well
Temperature (°F)	39.7	49.2	49.5	47.0	56.3
Specific Conductance (μmhos/cm)	1,589	>	5,770	10,240	9,090
pH (standard units)	8.9	7.8	7.9	8.4	8.4
Laboratory Parameter					
Total Dissolved Solids (mg/l)	----	13,500	1,570	5,390	----
Specific Conductance (μmhos/cm)	----	13,300	3,460	6,190	----
pH (standard units)	----	7.5	7.5	7.9	----
Total Alkalinity as $CaCO_3$ (mg/l)	----	389	2,170	727	----
Sulfate (mg/l)	----	7,910	<1	3,240	----
Chloride (mg/l)	----	645	71	62	----
Chromium (mg/l)	----	<0.02	<0.02	<0.02	----
Manganese (mg/l)	----	0.03	1.81	<0.02	----
5-day Biochemical Oxygen Demand (mg/l)	----	7	160	3	----

> Greater than 20,000

The results of the shallow ground water quality sampling indicate that the waters analyzed are dissimilar. The upgradient sample (TP-5) displayed the highest total dissolved solids, sulfate, and chloride. The overall quality is improved in the two apparently downgradient wells. However, the marked increase in biochemical oxygen demand, manganese, and alkalinity at TP-27 indicate that leachate may be present in the ground water at this location. Analysis for organic parameters would provide a better indication

concerning the presence of leachate.

Samples of ground water from the sandstone aquifers were collected from MW-1, MW-2, and the shop well. These samples were analyzed for a broad suite of parameters including the entire list of organic and inorganic constituents listed in the proposed Subtitle D regulations. The laboratory reports are presented in Appendix I. No organic parameters were detected which indicates that leachate is not present within the sandstone aquifers at these wells. The inorganic parameters generally indicate poor overall water quality. Comparing the results of the inorganic analyses, the concentrations of many of the parameters vary significantly between the three wells. Since the lack of organic constituents indicates the lack of leachate, the dissimilarity in inorganic parameter concentrations indicates that the waters in the wells may be from different sources. This agrees with the apparent discontinuities indicated by the aquifer physical parameters and drilling at the site.

IV. CONCLUSIONS AND RECOMMENDATIONS

A. Conclusions

1. PROPOSED LANDFILL EXPANSION AREA

a. Ground-Water Conditions

Based on the site hydrogeologic conditions as described in this report, the north side of the site appears to be suitable for the

proposed solid waste landfill project. The depth to the uppermost aquifer under the north side was found to be in excess of 200 feet at the north edge and deep ground water was encountered below 200 feet at the south edge of the site. The ground water occurs within sandstone beds of the Judith River formation. The sandstone beds are apparently discontinuous and, therefore, the water-bearing zones are also discontinuous. Water rose in both of the wells which indicates that the sandstones are capped by relatively impermeable shale.

Test boring TB-3 produced a trace of water over a three day period. It is possible that a very small amount of water may be present in the near-surface sand at this point or in a sandstone bed at 60 feet. Since this investigation was performed during an unusually wet year, we feel that this trace of water may be a result of the high precipitation. Proper surface drainage at the site would reduce infiltration and this trace of free ground water may diminish to a moisture content below field capacity. In any case, this seepage cannot be attributed to a viable aquifer and would not affect development of the site.

Two monitoring wells were installed at the site during this investigation. Monitoring well MW-1 is located along the north side of the proposed expansion site and is a downgradient well. MW-2 is located along the south side of the site and will serve as an upgradient background well.

b. Trench Base Materials

Materials present at the base elevations of the proposed trenches included silty to sandy clay, which fall into the range of slow to very slow permeabilities. Below these soils are interbedded shale and unsaturated sandstone beds. The sandstone beds are probably moderately permeable, but the shale units, which are up to 40 feet thick, appeared to be relatively impermeable. Hydraulic conductivity values of shales are discussed above and are estimated at 10^{-7} cm/sec. A more accurate determination of the relative permeability of the materials would require field testing.

c. Cover Materials

The near surface soils on the north side of the site were sandy to clayey silt underlain by sand, silt, clay and shale. These materials were easily excavated and will be suitable for use as daily and final cover. The high clay content of some of the soils may restrict vehicular traffic when wet and may be difficult to work when frozen.

d. Impact on Water Quality

It is our professional opinion that the proposed expansion site can be developed and operated as a solid waste landfill without significant effects on the sandstone aquifer at the site if the recommendations provided herein are followed.

b. Liner Base Materials

Materials present at the base elevations of the proposed trenches included silty to sandy clay, which left the range of silt to very slow permeabilities. Below these soils are interbedded shale and unconsolidated sandstone beds. The sandstone beds are probably moderately permeable, but the shale units, which are up to 40 feet thick, appeared to be relatively impermeable. Hydraulic conductivity values of shales are dependent above and are assumed at 10^{-7} cm/sec. A more accurate determination of the relative permeability of the materials would require field testing.

c. Cover Materials

The near surface soils on the north side of the site were mostly to clayey silt consisting of sand, silt, clay and shale. These materials were easily excavated and will be suitable for use as daily and final cover. The high clay content of some of the soils may restrict vehicular traffic when wet and may be difficult to work when frozen.

d. Impact to Water Quality

It is our professional opinion that the proposed expansion area can be developed and operated as a solid waste landfill without significant effects on the aquifers adjacent to the site if the recommendations provided herein are followed.

2. SOUTH SIDE SHALLOW GROUND WATER

The occurrence of shallow ground water at the site is generally limited to areas containing permeable sand and gravel deposits or shallow coal beds. The gradient of the shallow water generally follows the base of the gravel south of the existing landfill with seepage occurring from the gravel along the slope of the coulee. The depth of this shallow ground water is on the order of 5 to 20 feet. This shallow ground water may also be percolating into lower sandstone layers as seen in boring TB-1. Most of the water in test pits occurred as slow seeps, but approximately 1½ gpm was encountered while drilling TB-2 at a depth of 10 feet.

Shallow ground water may also be present in the colluvium in the bottom of the coulee, including the area of active landfilling. This investigation was insufficiently detailed to evaluate the ground water conditions within the colluvium at the site.

3. SHALLOW WATER QUALITY

Leachate from municipal landfills generally contains high concentrations of BOD_5, alkalinity, manganese and TDS (EPA, 1983; Cardinell, et al., 1989) . The field and laboratory test results presented herein indicate that leachate may be present in the shallow ground water at Test Pit 27. These preliminary tests are not conclusive and only indicate the possibility of leachate in the test pit.

3. SOURCE AND EXTENT OF SHALLOW GROUND WATER

B. Recommendations

1. NORTH SIDE LANDFILL EXPANSION

a. Depth of Landfilling

The depth to detectable ground water on the north side of the site is in excess of 200 feet and, therefore there is little possibility of approaching the aquifer with excavations. The landfill operation plan indicates trench depths of up to 20 feet. Bedrock may be encountered during excavation of some of the trenches. Based on the ease of excavation of the test pits at the site, the bedrock may be excavatable using a scraper, but should be easily excavatable using a crawler with a ripper.

b. Area of Landfilling

The upland area of the proposed expansion site is generally suitable for the project with the limitation of maintaining an undisturbed perimeter along the north and west sides. The purpose of the perimeter is to provide adequate materials to maintain the current level of slope stability at the crest of the slope of the coulee. Placement of a road around the perimeter of the landfill would satisfy this recommendation. If no road is to be built, a minimum of twenty feet of undisturbed material should be left between the landfill trenches and the crest of the slope.

c. Surface Drainage

The proposed landfill expansion area is a local topographic high and therefore, surface water entering the trenches from off the site is not likely. Daily and permanent cover for the landfill should be graded such that positive slope away from excavations or filled areas is provided and water is not allowed to pond on the site. Retention ponds and drainage ditches have been incorporated into the design of the landfill in order to collect any surface run-off emanating from the landfilled areas. These ponds have been designed to handle the 25 year - 24 hour storm event.

d. Cover Material

Based on nine test pits and two test borings on the north side of the site, the on-site soil should be adequate for use as daily and final cover material. Boulders and cobbles in excess of 8 inches should be removed from the soil prior to its use as final cover. The daily cover should be a minimum of 6 inches thick and the final cover should be a minimum of 2 feet thick. The final cover should be designed to prevent infiltration of moisture into the landfill.

e. Vegetation

It is recommended that vegetation be planted on the final cover to promote evapotranspiration and to reduce infiltration of precipitation into the filled areas. The type of vegetation should be determined by a qualified horticulturist or soil scientist.

f. Liquids Disposal

Liquid or semi-liquid wastes should not be disposed of at the solid waste landfill. Wastes should be as free from liquids as possible to prevent formation of leachate.

g. Ground Water Monitoring

A ground water monitoring plan should be developed for the sandstone aquifer. The water in monitoring wells MW-1 and MW-2 as well as the producing well at the landfill shop should be sampled and tested for physical properties, metals, and organic compounds as required by State rules. Further samples should be taken periodically and tested for properties and constituents as required by the State and outlined on the landfill permit. Prior to sampling, the water levels in the wells should be measured.

Sampling should be conducted by qualified personnel following applicable EPA sampling protocol. Testing should be conducted by a qualified laboratory certified by the Montana Department of Health and the EPA. Standard EPA test procedures should be used where applicable.

Considering the discontinuous nature of the sandstone water-bearing zones at the site, additional monitoring wells within the sandstone may be required to properly develop a ground-water monitoring plan.

2. EXISTING LANDFILL AREA

Since seepage of water into the landfill area could potentially cause leachate generation within the waste, we recommend mitigating the seepage at a point before it reaches the landfill. The shallow ground water occurs in a relatively large area of approximately 55 acres south of the existing landfill on the site and the adjacent property to the south. This area is too large to economically prevent infiltration of water into the ground or to dewater the entire area. We recommend intercepting the shallow ground water prior to its entry into the landfill in the area immediately south of the filled cells. The intercepted water should be conveyed away from the filled area and discharged into a natural drainage. The area of interception should be limited to the area immediately south of the land filled area.

Three options of intercepting the shallow ground water were considered, including dewatering wells, weep drains, and a cutoff trench with a subdrain. These options are briefly outlined below.

a. Dewatering Wells

Dewatering wells are gravel-packed drilled wells which serve as vertical drains with a submersible pump and discharge pipe. The advantages of these wells are: 1) ease and speed of installation; 2) little disturbance of the area and 3) effective at any depth. The disadvantages include 1) high maintenance costs including electricity for the pumps; 2) few qualified contractors are

7. Existing Landfill Area

Since escape of water into the landfill area could potentially cause leachate generation within the waste, we recommend eliminating the seepage of water before it reaches the landfill. The solution to water control is a relatively large area of approximately 25 acres south of the existing landfill to the site and the adjacent property to the south. This area is too large to economically prevent infiltration of water into the ground so to develop the entire area. We recommend intercepting the shallow ground water prior to its entry into the landfill in the area immediately south of the filled area. The intercepted water should be conveyed away from the filled area and discharged into a natural drainage. The area of construction should be limited to the area immediately south of the land filled area.

There options of intercepting the shallow ground water were considered, including excavating wells, deep trench, and a subsurface drain to accomplish. These options are briefly outlined below.

a. Excavation Pit

Excavating wells are usually spaced during wells which would be treated direct with a submersible pump and discharge pipe. The advantages of these wells are 1) ease and speed of installation; 2) little disturbance of the area and 3) effective at any depth. The disadvantages include 1) high maintenance costs including electricity for the pumps; 2) the qualified contractors are

located nearby and 3) numerous wells would be required and power lines would need to be installed resulting in a moderately high initial cost.

b. Weep Drains

Weep drains are horizontal drains drilled into the seeping embankment. Advantages of these drains are: 1) little maintenance is required; 2) no pumps or electricity are required and 3) only the seeping face is drained, resulting in a moderate initial cost. The disadvantages include: 1) the area where they are installed cannot be filled because of future maintenance 2) only shallow water can be drained and 3) few qualified contractors are located nearby.

c. Cutoff Trench with a Subdrain

This is a trench dug into and below the depth of shallow ground water. One side of the trench is lined with an impermeable membrane to prevent seepage of water past the trench. The bottom of the trench contains a subdrain including engineered gravel and a perforated pipe. Any water collected by the trench would be transported via a solid pipe away from the landfill. The advantages of the trench include: 1) little maintenance is required since no pumps or electricity is used; 2) no special equipment or expertise is require for most of the installation, therefore construction can be done by local contractors or with District equipment and labor; 3) excess gravel excavated from the trench can be sold or traded for contractor services resulting in a low initial cost and 4) water cannot pass through the trench

resulting in interception of all shallow water in its path. Disadvantages include: 1) the depth of drainage is limited to approximately 25 feet; 2) the high capital cost and installation difficulties of the impermeable membrane and 3) to achieve gravity flow to daylight, a long trench must be excavated across private land east of the site and under a high pressure gas line on the site.

Based on these options, we recommend installation of the cutoff trench with a subdrain as the most effective and cost efficient method of intercepting the shallow ground water. Installation of the trench can be coupled with exportation of excavated gravel, which has two benefits including profit on the sale of the gravel and construction savings by reducing the yardage of backfill to be replaced.

3. GROUND-WATER QUALITY BELOW EXISTING LANDFILL

The preliminary test results of shallow ground water indicate that leachate may be present in the ground at Test Pit 27. Considering that the ground water conditions within the colluvium are not well known and the preliminary analysis indicates the possible presence of leachate, we recommend further investigating this possible contamination by installing several shallow ground water monitoring wells in the area below (west of) the toe of the existing waste. These wells should be installed by a licensed Monitoring Well Constructor and should be similar in construction to monitoring wells MW-1 and MW-2.

The wells should be sampled and tested according to EPA protocol and a report should be prepared by a qualified hydrogeologist which delineates the extent of contamination or confirms its absence.

V. LIMITATIONS

The conclusions and recommendations in this report are to be used for design purposes for the Unified Disposal District landfill east of Havre, Montana as described in this report. The conclusions and recommendations in this report are based on:

- Five test borings,
- 33 test pits,
- Laboratory analysis of water samples,
- Review of available published geologic information,
- Observations of our Project Hydrogeologist and Principal Engineer,
- Information provided by Unified Disposal District, and
- Our experience in the area.

It is possible that lateral variations in the soil and bedrock conditions could exist between or beyond the points of exploration, and that the ground water conditions may change over time. This may require additional studies, consultation and possible design revisions.

This report was prepared in accordance with the generally accepted standard of practice for geologists and engineers which existed in Montana for similar projects at the time the report was written. No other warranty, expressed or implied, is made.

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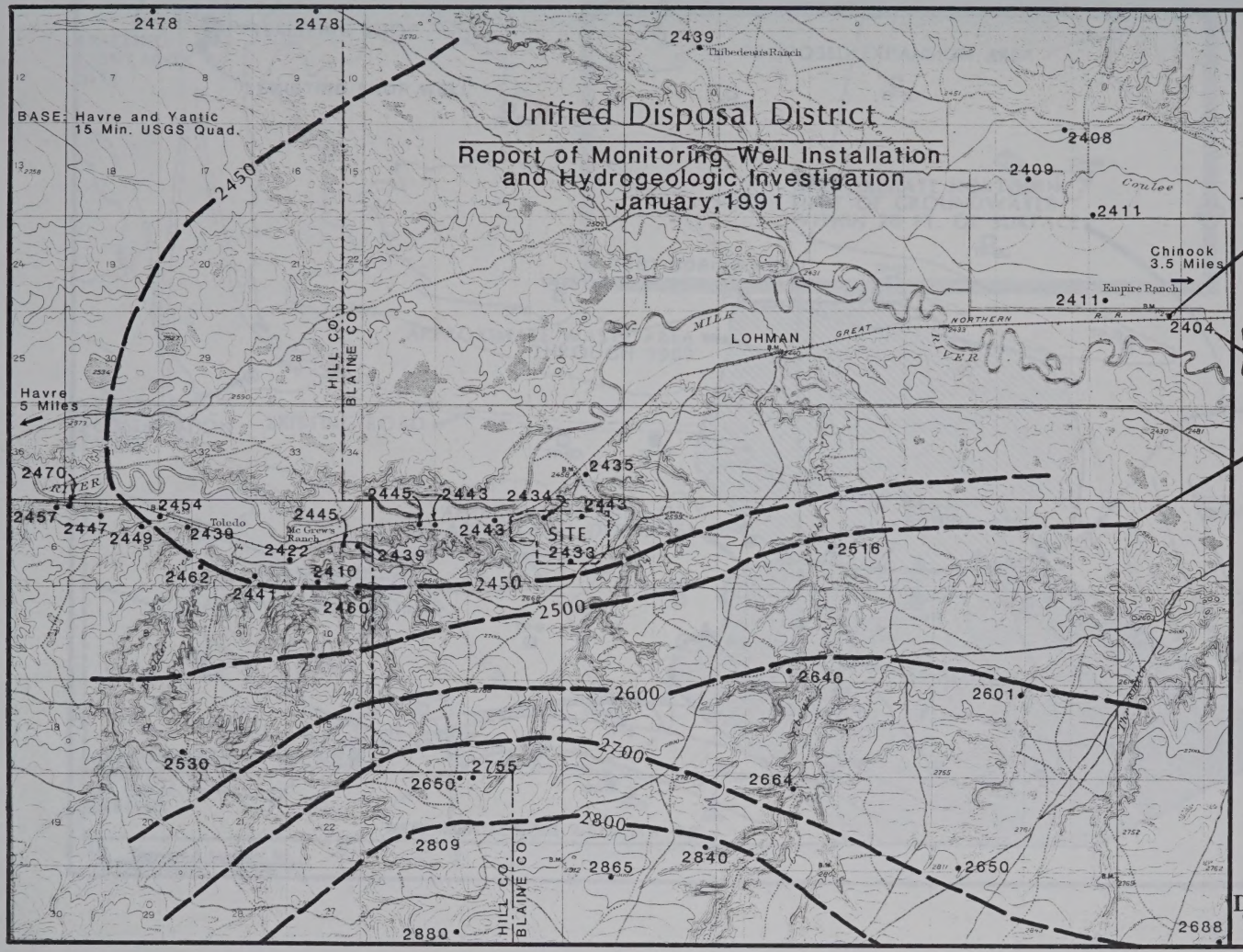
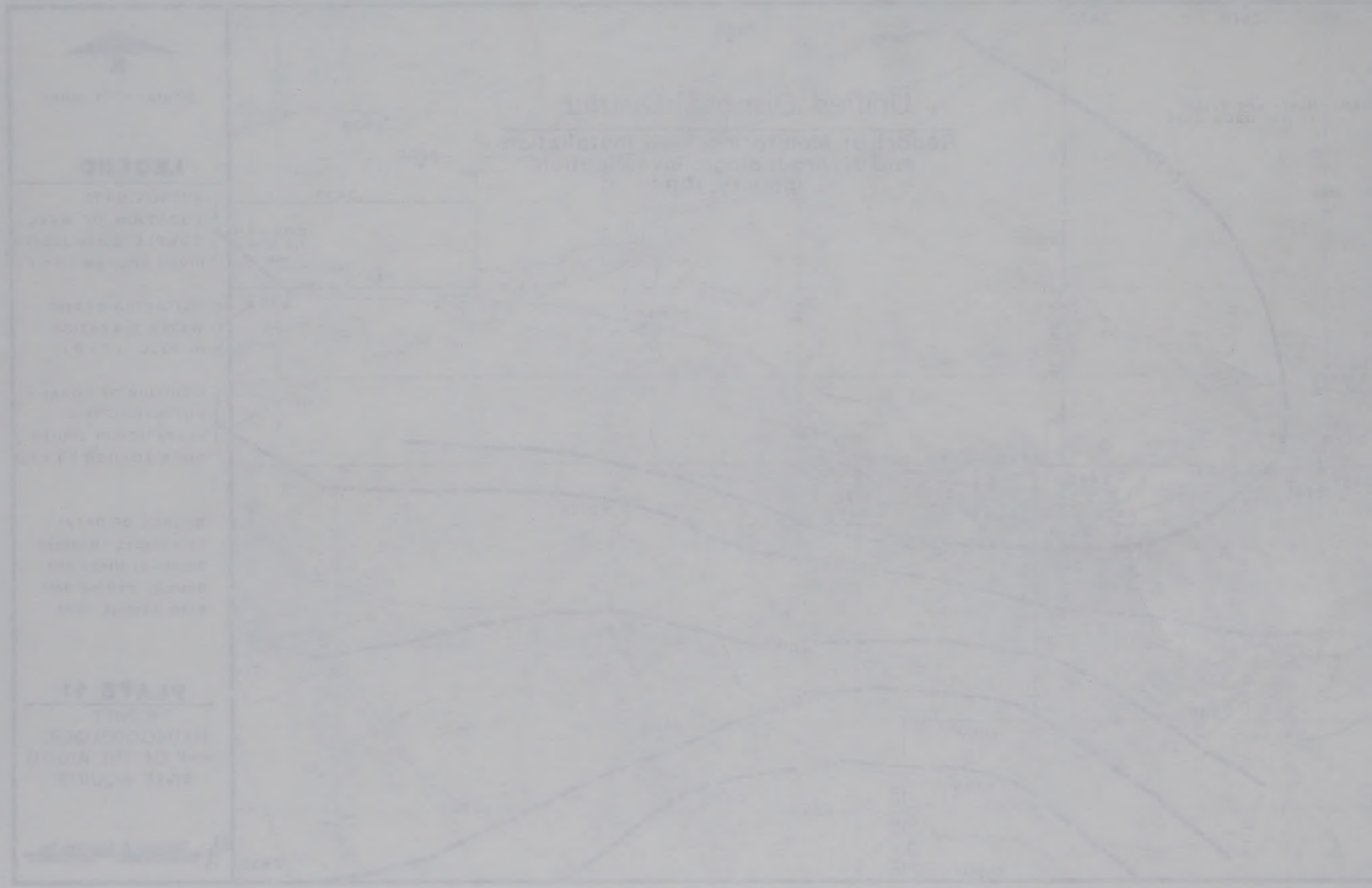
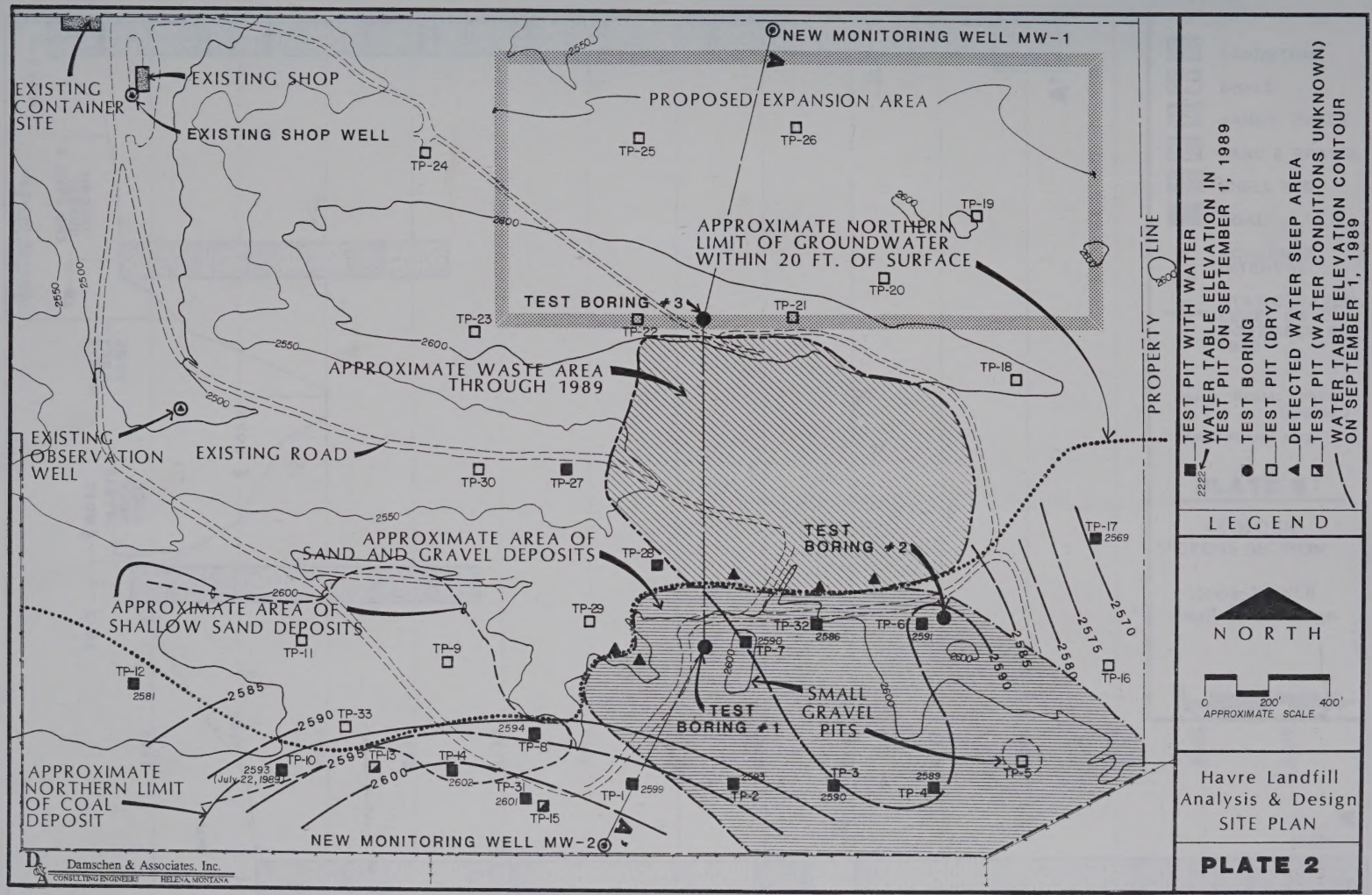

Unified Disposal District
Report of Monitoring Well Installation
and Hydrogeologic Investigation
January, 1991
BASE: Havre and Yantic
15 Min. USGS Quad.
N
Scale: 1"=1 mile
LEGEND
APPROXIMATE LOCATION OF WELL COMPLETED IN JUDITH RIVER AQUIFER (TYP.)
ESTIMATED STATIC WATER ELEVATION IN WELL (TYP.)
CONTOUR OF EQUAL POTENTIOMETRIC ELEVATION IN JUDITH RIVER AQUIFER (TYP.)
SOURCE OF DATA:
This study; Montana Bureau of Mines and Geology well log data base; Levings 1981
PLATE 1:
VICINITY HYDROGEOLOGIC MAP OF THE JUDITH RIVER AQUIFER
Damschen & Associates, Inc.
CONSULTING ENGINEERS HELENA, MONTANA
SITE
Havre 5 Miles
Chinook 3.5 Miles
LOHMAN
Empire Ranch
Thibedeaux Ranch
Toledo
Mc Grews Ranch
HILL CO.
BLAINE CO.
MILK RIVER
GREAT NORTHERN R. R.
2450
2500
2600
2700
2800
2478
2439
2408
2409
2411
2404
2435
2445
2443
2434
2454
2457
2447
2449
2439
2422
2462
2441
2410
2460
2516
2640
2601
2530
2755
2650
2664
2809
2865
2840
2880
2688
2470




NEW MONITORING WELL MW-1
EXISTING CONTAINER SITE
EXISTING SHOP
EXISTING SHOP WELL
PROPOSED EXPANSION AREA
TP-24
TP-25
TP-26
TP-19
APPROXIMATE NORTHERN LIMIT OF GROUNDWATER WITHIN 20 FT. OF SURFACE
TP-20
TEST BORING #3
TP-21
TP-22
TP-23
PROPERTY LINE
APPROXIMATE WASTE AREA THROUGH 1989
TP-18
EXISTING OBSERVATION WELL
EXISTING ROAD
TP-30
TP-27
APPROXIMATE AREA OF SAND AND GRAVEL DEPOSITS
TEST BORING #2
TP-28
TP-17
2569
APPROXIMATE AREA OF SHALLOW SAND DEPOSITS
TP-29
TP-32
2586
TP-6
2591
TP-11
TP-9
TP-7
2590
TP-12
2581
TP-16
TEST BORING #1
SMALL GRAVEL PITS
TP-33
2594
TP-8
TP-10
2593
(July 22, 1989)
TP-13
TP-14
2602
TP-5
APPROXIMATE NORTHERN LIMIT OF COAL DEPOSIT
TP-31
2601
TP-1
2599
TP-2
2593
TP-3
2590
TP-4
2589
TP-15
NEW MONITORING WELL MW-2
Damschen & Associates, Inc.
CONSULTING ENGINEERS HELENA, MONTANA
TEST PIT WITH WATER
2225 WATER TABLE ELEVATION IN TEST PIT ON SEPTEMBER 1, 1989
TEST BORING
TEST PIT (DRY)
DETECTED WATER SEEP AREA
TEST PIT (WATER CONDITIONS UNKNOWN)
WATER TABLE ELEVATION CONTOUR ON SEPTEMBER 1, 1989
LEGEND
NORTH
0 200' 400'
APPROXIMATE SCALE
Havre Landfill
Analysis & Design
SITE PLAN
PLATE 2

A
A'
MW-1
MW-2
TB-1
TB-3
BEGIN SAND & GRAVEL DEPOSIT
END SAND & GRAVEL DEPOSIT
WASTE AREA EDGE
WASTE AREA EDGE
℄ ROAD
℄ ROAD
2600
2580
2560
2540
2520
2500
2480
2460
2440
2420
2400
2380
2360
2340
SANDSTONE
SHALE
SANDY SHALE
SAND & GRAVEL
SHELL BED
COAL
SCREENED INTERVAL
STATIC WATER LEVEL ON NOVEMBER 9, 1990
Horiz. Scale: 1"=300' (approx.)
Vert. Scale: 1"=20'
PLATE 3:
GEOLOGIC CROSS SECTION
Havre Landfill Analysis & Design
D&A Damschen & Associates, Inc.
CONSULTING ENGINEERS HELENA, MONTANA

Appendix A

Well Log Summary

Digitized by Google

LOCATION T R S TRACT	TD (FT)	PL (FT)	SWL (FT)	DEPTH WATER ENTERS WELL (FT)	SHUT IN PRESS PSIG	Y ELEV D	M	D	W	A.I (FT)	H C W	DIA. (IN)	CASED	PERFORATED INTERVAL	LEDGE	FORMATION	GEOLOGIC SOURCE	WELL USE	TYPE	YEAR COMP	MINERAL LEASE NUMBER	O.W.	RATING
File ID: 33N18E04 071869	345	200	LYBECK MRS HAROLD 15			Lab Number: 20 1						7	1	DNR NO: 322- 345	1	7	INV NO:	S	C	CNTY: 1961	005	#	+
File ID: 33N18E07 071870	90	45	PAULSON WALTER 12			Lab Number: 10 2						6	1	DNR NO: -	1	2	INV NO:	H	C	CNTY: 1965	005 015	#	4
File ID: 33N18E07AB 071871	133	65	PAULSON WALTER 16			Lab Number: 25 1 2455					2	7	1	DNR NO: 107- 133	1	75	INV NO: 211JDRV	S	C	CNTY: 1964	005 015	#	1
File ID: 33N18E07DA 071872	44	15	PAULSON WALTER 10			Lab Number: 15 1						6	1	DNR NO: -	1	21	INV NO:	S	C	CNTY: 1965	005 015	#	1
File ID: 33N18E13AC 071873	270	120	HOFELDT BEN 2			Lab Number: 12 3						6	1	DNR NO: 260- 270	1	67	INV NO:	S	H	CNTY: 1974	005 196	#	1
File ID: 33N18E13CCC 071866	40	10	HOFELDT BEN 4			Lab Number: 35 3 2415				1		6	1	DNR NO: 9487 35- 40	1	2	INV NO:	S	H	CNTY: 1976	005 196	#	0
File ID: 33N18E14AAA 071874	283	80	HALL IRA 20			Lab Number: 15 3						6	1	DNR NO: 270- 280	1	7	INV NO:	S	H	CNTY: 1974	005 196	#	0
File ID: 33N18E14DAAC 071875	165	130	HALL ARLEY 10			Lab Number: 8 1 2416					2	6	1	DNR NO: 130- 163	1	7	INV NO: 78I00366 211JDRV	S	E	CNTY: 1961	005	#	3
File ID: 33N18E15A 071876	65	8	MAJERUS GILES 3			Lab Number: 15 7 2425					2	6	1	DNR NO: -	1	12	INV NO: 110ALVM	S	C	CNTY: 1973	005 015	#	4
File ID: 33N18E15DBD 071887			Owner: WIEDERIEN FRED E. 5			Lab Number: 5 7 2424					2	6	1	DNR NO: -		2	INV NO:	S	T	CNTY: 1961	005	#	4
File ID: 33N18E17CD 071888	70		Owner: NEIBAUER GEORGE			Lab Number: 2 7 2455					2	-	3	DNR NO: -		2	INV NO:	S	Q	CNTY: 1948	005	#	4
File ID: 33N18E20AD 071889	20		Owner: NEIBAUER GEORGE #2			Lab Number: 2 7 2435					2	-	3	DNR NO: -		2	INV NO:	S	Q	CNTY: 1938	005	#	4
File ID: 33N18E20AD 071891	20		Owner: NEIBAUER GEORGE #3			Lab Number: 2 7 2435					2	-	3	DNR NO: -		2	INV NO:	S	Q	CNTY: 1938	005	#	4
File ID: 33N18E20DAD 071893 01	30		Owner: KLEINJAN PAUL 20			Lab Number: 25 7 2435					2	1	3	DNR NO: -		2	INV NO: 110ALVM	SH	V	CNTY: 1923	005	#	2
File ID: 33N18E20DAD 071892 02	30		Owner: KLEINJAN PAUL 20			Lab Number: 25 7 2435					2	1	3	DNR NO: -		2	INV NO: 110ALVM	SH	V	CNTY: 1923	005	#	2
File ID: 33N18E20DAD 071894 03	30		Owner: KLEINJAN PAUL 20			Lab Number: 25 7 2435					2	1	3	DNR NO: -		2	INV NO: 110ALVM	SH	V	CNTY: 1923	005	#	2
File ID: 33N18E20DAD 071895 04	30		Owner: KLEINJAN PAUL 20			Lab Number: 25 7 2435					2	1	3	DNR NO: -		2	INV NO: 110ALVM	SH	V	CNTY: 1923	005	#	2

LOCATION T R S TRACT	TD (FT)	PL (FT)	SWL (FT)	DEPTH WATER ENTERS WELL (FT)	SHUT IN PRESS PSIG	YIELD GPM	H2O TEMP	ALT (FT)	FLOW	DIA. (IN)	CASED	PERFORATED INTERVAL	LOG	LITHOLOGY	GEOLOGIC SOURCE	SEQUENCE	TYPE	YEAR COMP	WELL RECORD NUMBER	E.W.G.	SECTION
File ID: 33N18E20DD	071877 104	Owner: 100	THOMPSON RALPH 10			Lab Number: 20	1	2436	2	7	1	DNR NO: 95- 104	1	5	INV NO: 110ALVM	S	C	CNTY: 1965	005 031	#	2
File ID: 33N18E21CB	071890 180	Owner:	NEIBAUER GEORGE 180			Lab Number: 2	7	2430	2	7	1	DNR NO: -	1	4	INV NO: 211JDRV	S	Q	CNTY: 1945	005	#	3
File ID: 33N18E21CC	071878 175	Owner: 100	THOMPSON RALPH 10			Lab Number: 10	1	2425	2	7	1	DNR NO: -	1	5	INV NO: 211JDRV	S	C	CNTY: 1966	005 031	#	0
File ID: 33N18E21DD	071879 176	Owner: 175	SARGENT DUANE 15			Lab Number: 10	1	2425	2	7	1	DNR NO: -	1	7	INV NO: 211JDRV	S	C	CNTY: 1971	005 031	#	0
File ID: 33N18E22AC	071896 01 160	Owner:	WAISATH HERMAN			Lab Number: 8	7	2425	2	-	3	DNR NO: -	2		INV NO:	HS	E	CNTY: 1937	005	#	4
File ID: 33N18E22AC	071897 02 14	Owner:	WAISATH HERMAN			Lab Number: 8	7	2425	2	60	3	DNR NO: -	2		INV NO:	HS	D	CNTY: 1937	005	#	4
File ID: 33N18E22AC	071898 03 15	Owner:	WAISATH HERMAN			Lab Number: 8	7	2425	2	15	3	DNR NO: -	2		INV NO:	SH	D	CNTY: 1937	005	#	4
File ID: 33N18E24CB	071899 7	Owner:	SEE GEORGE			Lab Number: 5	7	2420	2	36	1	DNR NO: -	2		INV NO: 110ALVM	S	D	CNTY: 1953	005	#	4
File ID: 33N18E24CC	071880 153	Owner: 90	KAUFMAN TED 9			Lab Number: 12	2	2420	2	7	1	DNR NO: 132- 153	1	75	INV NO: 211JDRV	SH	C	CNTY: 1965	005 021	#	3
File ID: 33N18E24CCC	071881 29	Owner:	OLSON HARRY 6			Lab Number: -	3			6	1	DNR NO: 10839 24- 29	1	2	INV NO: 110ALVM	S	H	CNTY: 1975	005 196	#	3
File ID: 33N18E24DC	071900 C1 165	Owner:	NASH ROY 140			Lab Number: 4	7	2415	2	6	1	DNR NO: -	2		INV NO:	SH	E	CNTY: 1920	005	#	4
File ID: 33N18E24DD	071901 02 162	Owner:	NASH ROY 150			Lab Number: 5	7	2415	2	7	1	DNR NO: -	2		INV NO:	SH	E	CNTY: 1956	005	#	4
File ID: 33N18E24DDS	071882 47	Owner: 15	PLENINGER LES 4			Lab Number: 30	5			6	1	DNR NO: 41- 45	1	214	INV NO:	HS	H	CNTY: 1976	005 196	#	0

LOCATION T R S TRACT	TD (FT)	PL (FT)	SWL (FT)	DEPTH WATER ENTERS WELL (FT)	SHUT IN PRESS PSIG	YIELD MD	HOW	ALT (FT)	HOW	DIA. (IN)	CASED	PERFORATED INTERVAL	LOG	LITHZONE	GEOLOGIC SOURCE	WELL USE	TYPE	YEAR COMP	PRINCIPAL AQUIFER	Q. W.	RATING
File ID: 074151 32N18E04DA	225	Owner: 150	BURNS THOMAS 19			Lab Number: 3 1				4	1	DNR NO: -	1	579	INV NO: 211JDRV	S	C	CNTY: 005 1961	015	#	4
File ID: 071498 32N18E09CAC	200	Owner: 195	RAMBERG M/M WARNER 60			Lab Number: 4 1				6	1	DNR NO: 95- 195	26465 1	59	INV NO:	S	C	CNTY: 005 1979	031	#	1
File ID: 071600 32N18E14AA	20	Owner: 18	HAUGEN MARK 16			Lab Number: 20 1	2617	2		48	1	DNR NO: -	2		INV NO:	S	D	CNTY: 005 1969		#	1
File ID: 029707 32N18E20DCB	69	Owner:	DAVIDSON NOEL R 17			Lab Number: -				6	1	DNR NO: 25- 69	58185 1	950	INV NO:	Q	R	CNTY: 005 1981	390	#	
File ID: 071596 32N18E21	60	Owner: 40	WERK CHARLES 20			Lab Number: 2 1				4	1	DNR NO: 36- 38	1	7	INV NO:	S	C	CNTY: 005 1959	015	#	4
File ID: 071597 32N18E21BAD	34	Owner: 30	ORTWER GEORGE 11			Lab Number: 5 7	2675	2		5	1	DNR NO: 24- 34	1	70	INV NO: 211JDRV	S	C	CNTY: 005 1972	015	#	2
File ID: 071595 32N18E23CD	160	Owner:	LUX JOHN J. #2 150			Lab Number: 2 7				6	1	DNR NO: -	2		INV NO: 211JDRV	S	E	CNTY: 005 1911		#	4
File ID: 071601 32N18E25DCBA	160	Owner:	RAMBERG MARIE 140			Lab Number: 4 7	2920?	2		4	1	DNR NO: -	2		INV NO: 211JDRV	S	E	CNTY: 005 1948		#	4
File ID: 071599 32N18E26BA	18	Owner:	LUX JOHN J #3 15			Lab Number: 2 7				-	1	DNR NO: -	2		INV NO:	S	D	CNTY: 005 1911		#	4
File ID: 071598 32N18E30BAA	120	Owner: 90	BARGER WARREN 35			Lab Number: 6 2				6	1	DNR NO: 100- 120	1	752	INV NO:	Q	C	CNTY: 005 1981	390	#	1
File ID: 071602 32N18E35CC	14	Owner:	FINCH CLARENCE			Lab Number: 5 7	2870	2		-	1	DNR NO: -	2		INV NO:	S	Q	CNTY: 005 1920		#	4

T R S TRACT LOCATION	TD (FT)	PL (FT)	SWL (FT)	DEPTH WATER ENTERS WELL (FT)	SHUT IN PRESS PSIG	YIELD GPM	HOURS	ALT (FT)	HOW	DIA. (IN)	CASED	PERFORATED INTERVAL	LOG	LITHOLOGY	GEOLOGIC SOURCE	WELL USE	TYPE	YEAR COMP	DRILLING CONTRACTOR	Q. W.	RATING
File ID: 33N18E25AAAC	071884 186	Owner: 90	FISHER BEN 13			Lab Number: 5 2				6	1	DNR NO: 112- 113 145- 153 178- 186	22082 1 7		INV NO:	H	C	CNTY: 1979	005 339	#	2
File ID: 33N18E25CC	071902 20	Owner:	HAUGEN MARK			Lab Number: 10 7 2425	2	30	3	DNR NO: -		2			INV NO:	H	Q	CNTY: 1890	005	#	4
File ID: 33N18E25DA	071903 90	Owner:	HAUGEN HAROLD 20			Lab Number: - 7 2420	2	6	1	DNR NO: -		2			INV NO: 110ALVM	SH	Q	CNTY: 1958	005	#	4
File ID: 33N18E26ACD	029717 28	Owner: 20	PLOUFFE DOUGLAS 9			Lab Number: 5 2		6	1	DNR NO: -		62787 1 12			INV NO:	H	C	CNTY: 1987	005 390	#	
File ID: 33N18E26BB	071885 27	Owner: 17	MILLER CLYDE/ARLENE 10			Lab Number: 18 2 2425	2	6	1	DNR NO: -		5482 1 21			INV NO: 110ALVM	SH	C	CNTY: 1974	005 046	#	2
File ID: 33N18E26DD	071904 20	Owner:	HAUGEN MARK			Lab Number: 10 7 2425	2	30	3	DNR NO: -		2			INV NO:	S	Q	CNTY: 1940	005	#	4
File ID: 33N18E27AA	071932 40	Owner:	RATY H.J. #1			Lab Number: 5 7 2405	2	-	1	DNR NO: -		2			INV NO: 110ALVM	S	Q	CNTY: 1900	005	#	4
File ID: 33N18E29AC	072618 68	Owner:	GREAT NORTHERN R.R. 13			Lab Number: 20 2 2440	2	6	1	DNR NO: -		1 2			INV NO: 110ALVM	N	E	CNTY: 1944	005	#	3
File ID: 33N18E29ACC	071886 54	Owner: 14	DION PETE JR 8			Lab Number: 10 2		6	1	DNR NO: -		1 2			INV NO:	Q	C	CNTY: 1981	005 390	#	0
File ID: 33N18E29BD	071905 62	Owner:	ROBERTS LORETTA 40			Lab Number: 15 7 2440	2	6	1	DNR NO: -		2			INV NO: 110ALVM	HS	E	CNTY: 1900	005	#	3
File ID: 33N18E29CAAA	071906 27	Owner:	SCHOOL DISTRICT #41			Lab Number: 20 7 2445	2	6	1	DNR NO: -		2			INV NO: 110ALVM	H	E	CNTY: 1955	005	#	4
File ID: 33N18E29DB	071907 21	Owner:	NEMETZ JAMES 18			Lab Number: 20 7 2445	2	-	3	DNR NO: -		2			INV NO: 110ALVM	H	V	CNTY: 1949	005	#	4
File ID: 33N18E29DB	071908 23	Owner:	NEMETZ JAMES 18			Lab Number: 20 7 2445	2	-	3	DNR NO: -		2			INV NO: 110ALVM	S	V	CNTY: 1951	005	#	4
File ID: 33N18E29DB	072617 69	Owner:	GREAT NORTHERN RR 12			Lab Number: 2 2 2445	2	6	1	DNR NO: -		1 12			INV NO: 110ALVM	N	E	CNTY: 1952	005	#	4
File ID: 33N18E32DA	071909 01 18	Owner:	CARLSON MELVIN 18			Lab Number: - 7 2485	2	-	3	DNR NO: -		2			INV NO:	HS	V	CNTY: 1951	005	#	4
File ID: 33N18E32DA	071910 02 18	Owner:	CARLSON MELVIN 18			Lab Number: - 7 2485	2	-	3	DNR NO: -		2			INV NO:	HS	V	CNTY: 1958	005	#	4

LOCATION T	R	S	TRACT	TD (FT)	PL (FT)	SWL (FT)	WATER ENTERS WELL (FT)	SHUT IN PRESS PSIG	HIGH ENP LMD	MO	DAY	ALT (FT)	HOW	DIA. (IN)	ASED	PERFORATED INTERVAL	LOG	LITHO	GEOLOGIC SOURCE	WELL USE	WELL TYPE	YEAR COMP	WELL RECORD	•	WING
File ID: 33N18E33B8			071911	29	Owner: 23	CLEAR CREEK HEREFORD 5			Lab Number: 14	1	2470	2	6	1	DNR NO: -	1	12	INV NO: 110ALVM	S	C	CNTY: 1971	005 046	#	1
File ID: 33N18E33B8			071912	37	Owner: 16	BURNS TOM 12			Lab Number: 12	1	2470	2	5	1	DNR NO: -	1	2	INV NO: 110ALVM	S	C	CNTY: 1967	005 015	#	0
File ID: 33N18E33B8C			071913	42	Owner:	BURNS HARRY			Lab Number: -	7	2470	2	-	3	DNR NO: -	2		INV NO: 110ALVM	SH	E	CNTY: 1947	005	#	4
File ID: 33N18E33B8C			071914	42	Owner:	BURNS HARRY			Lab Number: -	7	2470	2	-	3	DNR NO: -	2		INV NO: 110ALVM	SH	E	CNTY: 1947	005	#	4
File ID: 33N18E33B8C			071915	26	Owner:	BURNS HARRY			Lab Number: -	7	2470	2	-	3	DNR NO: -	2		INV NO: 110ALVM	SH	E	CNTY: 1947	005	#	4
File ID: 33N18E35ADD			071916		Owner: 5	STERNS GAY 5			Lab Number: 10				30	1	DNR NO: -	2		INV NO:	SH	D	CNTY: 1963	005	#	4

I
Total number in report 4

LOCATION T R S TRACT	TD (FT)	PL (FT)	SWL (FT)	DEPTH WATER ENTERS WELL (FT)	SHUT IN PRESS PSIG	YIELD MD	YIELD MO	YIELD HOW	ALT (FT)	HOW DIA. (IN)	CASED	PERFORATED INTERVAL	LOG	LTHE	ZTON E	GEOLOGIC SOURCE	WELLS LE	TYPE	YEAR COMP	DRILLING LEMBER	Q • W •	RATING
File ID: 33N17E36ACC	055094 62	Owner:	PATRICK THOMAS ✓ 18			Lab Number: 5 2				6	1	DNR NO: -	70934 1	12		INV NO:	S	C	CNTY: 1989	005 339	*	
File ID: 33N17E36CAB	074287 153	Owner:	BRADY EARL 153 ?			Lab Number: 2 7	2450	2	1	3	DNR NO: -	2			INV NO:	I	Q	CNTY: 1953	005	*	4
File ID: 33N17E36DBA	071867 35	Owner:	DION ROBERT ✓ 16 12			Lab Number: 15 2				6	1	DNR NO: -	1	2		INV NO:	Q	C	CNTY: 1981	005 390	*	1
File ID: 33N17E36DBD	071863 48	Owner:	PATRICK THOMAS R ✓ 26 19			Lab Number: 17 3				6	1	DNR NO: 43-	27336 48 1	012		INV NO:	HS	C	CNTY: 1979	005 046	*	1

LOCATION T R S TRACT	TD (FT)	PL (FT)	SWL (FT)	DEPTH WATER ENTERS WELL (FT)	SHUT IN PRESS PSIG	YIELD MIN	YIELD HOUR	HEAD (FT)	HOLE DIA. (IN)	CASED	PERFORATED INTERVAL	LOG	LITH	ZONE	GEOLOGIC SOURCE	WELL USE	TYPE	YEAR COMP	DRILLER'S LOG NUMBER	Q. W.	RATING
File ID: 33N17E04D	074290 240	Owner: 190	STATE OF MONTANA 81			Lab 8	Number: 1		5	1	DNR NO: 220- 240	1	7		INV NO:	S	C	CNTY: 1977	041 015	#	4
File ID: 33N17E06DDAD	074291 237	Owner: 125	VELK WILLIAM 77			Lab 12	Number: 4	2555	2	6	1	DNR NO: 217- 237	1	1349 7	INV NO: 211JDRV	78I00365 S	C	CNTY: 1973	041 015	#	0
File ID: 33N17E19DDB	044250 1235	Owner:	BALTRUSCH OTTO			Lab 1	Number: 7	2577	1	-	3	DNR NO: -	1		INV NO:	71P02521 S	Z	CNTY: 1971	041	#	
File ID: 33N17E36ACC	055094 62	Owner:	PATRICK THOMAS 18			Lab 5	Number: 2		6	1	DNR NO: -	1	70934 12		INV NO:	S	C	CNTY: 1989	005 339	#	
File ID: 33N17E36CAB	074287 153	Owner:	BRADY EARL 153			Lab 2	Number: 7	2450	2	1	3	DNR NO: -	2		INV NO:	Z	Q	CNTY: 1953	005	#	4
File ID: 33N17E36DBA	071867 35	Owner: 16	DION ROBERT 12			Lab 15	Number: 2		6	1	DNR NO: -	1	2		INV NO:	Q	C	CNTY: 1981	005 390	#	1
File ID: 33N17E36DBD	071868 48	Owner: 26	PATRICK THOMAS R 19			Lab 17	Number: 3		6	1	DNR NO: 43- 43	1	27336 012		INV NO:	HS	C	CNTY: 1979	005 046	#	1

LOCATION T R S TRACT	TD (FT)	PL (FT)	SWL (FT)	DEPTH WATER ENTERS WELL (FT)	SHUT IN PRESS PSIG	YIELD GPM	HOURS	ALT (FT)	HOW	DIA. (IN)	CASED	PERFORATED INTERVAL	LOG	LITHE	ZONE	GEOLOGIC SOURCE	WELL USE	TYPE	YEAR COMP	DRILLER'S LOG NUMBER	CW.	RATING
File ID: 32N17E01AD	040425	50	Owner: UNIFIED DISPOSAL BD. ✓		Lab Number: -					4	1	DNR NO: 30- 49	1	14		INV NO:	L	A	CNTY: 005 1983	046	#	
File ID: 32N17E01AD	040426	88	Owner: UNIFIED DISPOSAL BD. ✓	40	Lab Number: 2 1					6	1	DNR NO: 71- 89	1	75		INV NO:	Q	A	CNTY: 005 1983	046	#	
File ID: 32N17E01BD	071496 *	120	Owner: JOHNSON GEORGE ✓	110 6	Lab Number: 2 1					6	1	DNR NO: -	1	7		INV NO: 211JDRV	S	C	CNTY: 005 1963	046	#	2
File ID: 32N17E02 ?		32	Owner: GREG RIGGIN TRUST	22 12	Lab Number: 20 2					-	1	DNR NO: 24- 29	1	2		INV NO:	S	H	CNTY: 005 1974	196	0	4
File ID: 32N17E02 ?		80	Owner: HOFELDT BEN	70 25	Lab Number: 8 3					7	1	DNR NO: 69- 75	1	12		INV NO:	H	H	CNTY: 005 1974	196	0	4
File ID: 32N17E024DC	029706	127	Owner: KOA CAMP GROUNDS ✓	85 15	Lab Number: 25 1					6	1	DNR NO: - 5818I	1	7		INV NO:	P	C	CNTY: 005 1974	015	#	
File ID: 32N17E023C		205	Owner: FREIRER HERBERT	201 63	Lab Number: 3 1					9	1	DNR NO: 60- 200	1	57		INV NO: 211JDRV	SH	C	CNTY: 005 1973	046	0	3
File ID: 32N17E023DCB	071497	128	Owner: K.O.A. CAMP GROUNDS ✓	105 16	Lab Number: 15 1 2460 2					6	1	DNR NO: 108- 128	1	57		INV NO: 05V01982 211JDRV	P	C	CNTY: 005 1977	015	#	0
File ID: 32N17E03CB	074137	190	Owner: ROLF WALLACE ✓	156 30	Lab Number: 27 3					6	1	DNR NO: 155- 189 16976	1	7		INV NO:	H	H	CNTY: 041 1977	196	#	2
File ID: 32N17E03CB	074138	68	Owner: ROLF WALLACE ✓	60 38	Lab Number: 5 1 2460 2					6	1	DNR NO: 53- 68 12974	1	7		INV NO: 211JDRV	H	C	CNTY: 041 1977	015	#	2
File ID: 32N17E03CD	074131	220	Owner: STERRETT DICK	90	Lab Number: 12 7 2460 2 ??					7	1	DNR NO: - 2				INV NO:	SH	Q	CNTY: 041 1959		#	3
File ID: 32N17E03DA	074132	176	Owner: STERRETT DICK	60	Lab Number: 15 7 2460 2 ??					6	1	DNR NO: - 2				INV NO:	S	Q	CNTY: 041 1962		#	3
File ID: 32N17E03DA	074133	115	Owner: STERRETT DICK	110 41	Lab Number: 13 1					7	1	DNR NO: 78- 115	1	7		INV NO:	S	C	CNTY: 041 1959	021	#	2
File ID: 32N17E04BCD	074134	22	Owner: ANDERSON RALPH W.	15	Lab Number: 10 7 2460 2					6	1	DNR NO: - 2				INV NO:	S	Q	CNTY: 041 1946		#	3
File ID: 32N17E04CCA	007975	42	Owner: MONTANA AG. II	27 13	Lab Number: 30 1					5	1	DNR NO: 34- 41	1	57		INV NO:	H	C	CNTY: 041 1984	046	#	0
File ID: 32N17E04CDA?	007976	120	Owner: MCMAHAN STEVE	110 75	Lab Number: 4 1					6	1	DNR NO: 107- 120	1	7		INV NO:	Q	C	CNTY: 041 1984	390	#	0
File ID: 32N17E04DC	074139	206	Owner: CROSS VIRGIL	201 69	Lab Number: 3 1					6	1	DNR NO: 72- 201	1	7		INV NO:	SH	C	CNTY: 041 1972	046	#	1

LOCATION T R S TRACT	ID (FT)	PL (FT)	SWL (FT)	WATER ENTERS WELL (FT)	SHUT IN PRESS PSIG	TIG EMP D	L M	H D W	ALT (FT)	H O W	DIA. (IN)	SEC D	PERFORATED INTERVAL	LOG	TIME	SOURCE	GEOLOGIC	EULS LE	TYPE	YEAR COMP	ENCE RER	W.	ING
File ID: 32N17E04DC	074135 32	Owner: 7	CROSS VIRGIL			Lab Number: 6 7					6	1	DNR NO: -		2		INV NO:	S	Q	CNTY: 041 1953		#	4
File ID: 32N17E05	074140 38	Owner: 20	KUHN ROBERT 12			Lab Number: - 1					5	1	DNR NO: -		1	7	INV NO:	H	C	CNTY: 041 1974	015	#	4
File ID: 32N17E05	040427 213	Owner: 138	HASLER JOHN & GLORIA 106			Lab Number: 10 1					5	1	DNR NO: 114- 212	1	7		INV NO:	H	A	CNTY: 041 1984	046	#	
File ID: 32N17E05	074144 75	Owner:	JACOB ALBERT J. 9			Lab Number: 3 7 2465					4	1	DNR NO: -		2		INV NO:	SH	E	CNTY: 041 1942		#	3
File ID: 32N17E05ABD	007977 208	Owner: 110	MONTANA HIGHWAY DEPT 16			Lab Number: 35 2					4	1	DNR NO: 116- 127 130- 207	1	7		INV NO:	PR	C	CNTY: 041 1983		#	4
File ID: 32N17E05AC	074141 70	Owner: 60	KRAFT LEO 31			Lab Number: 5 1					6	1	DNR NO: 12406 55- 70	1	7		INV NO: 211JDRV	N	C	CNTY: 041 1977	015	#	2
File ID: 32N17E05B	074143 134	Owner: 60	FEWER WILLIAM 27			Lab Number: 15 1					4	1	DNR NO: 100- 134	1	57		INV NO:	H	Z	CNTY: 041 1959	015	#	1
File ID: 32N17E05BAC	074142 135	Owner: 162	MORRISON KENNETH 99			Lab Number: 17 1					5	1	DNR NO: 94- 185	1	7		INV NO:	HC	C	CNTY: 041 1980	046	#	0
File ID: 32N17E05BBB	074136 25	Owner:	TOTH EDWARD 12			Lab Number: 2 7					36	1	DNR NO: -		2		INV NO:	Q	D	CNTY: 041 1935		#	3
File ID: 32N17E05BBD	007978 215	Owner: 151	GLANCY THOMAS & S. 98			Lab Number: 13 2					5	1	DNR NO: 174- 214	1	75		INV NO:	Q	A	CNTY: 041 1983	046	#	0
File ID: 32N17E05BDC	063435 160	Owner:	FARMER LEE/RHONDA J. 46			Lab Number: 14 2					5	1	DNR NO: 57- 159	1	57		INV NO: 71647	HS	C	CNTY: 041 1989	345	#	
File ID: 32N17E06	074146 142	Owner: 138	COTTON KEN/BRAD 37			Lab Number: 11 1					6	1	DNR NO: 80- 138	1	7		INV NO:	S	C	CNTY: 041 1976	046	#	4
File ID: 32N17E06	074147 128	Owner: 124	STALLER REV DALLAS E 89			Lab Number: 6 1					5	1	DNR NO: 84- 123	1	7		INV NO:	HS	C	CNTY: 041 1975	046	#	4
File ID: 32N17E06	074149 116	Owner: 100	DOLL ADRIAN 92			Lab Number: 5 1					6	1	DNR NO: 92- 115	1	7		INV NO:	S	C	CNTY: 041 1960	015	#	2
File ID: 32N17E06	074145 85	Owner:	JACOB ALBERT J. 13			Lab Number: 20 7 2500	2		18	3	DNR NO: -		2				INV NO:	S	E	CNTY: 041 1920		#	3
File ID: 32N17E06AA	074148 127	Owner: 118	DOLL ADRIAN & DOT 99			Lab Number: 7 1					6	1	DNR NO: 88- 122	1	7		INV NO:	S	C	CNTY: 041 1975	046	#	3

LOCATION T R S TRACT	TD (FT)	PL (FT)	SWL (FT)	DEPTH WATER ENTERS WELL (FT)	SHUT IN PRESS PSIG	YIELD	METHOD	ALT (FT)	METHOD	DIA. (IN)	CASED	PERFORATED INTERVAL	LOG	LITHOLOGY	ZONE	GEOLOGIC SOURCE	WELL USE	TYPE	YEAR COMP	ACCURACY RECORDER	Q.W.	RATING
File ID: 32N17E06ABB	007979	Owner: SCHUBRING DENNIS			Lab Number: 8 1					6	1	DNR NO: 117- 155	1	7		INV NO:	Q	C	CNTY: 041	390	#	0
File ID: 32N17E06ABB	040428	Owner: CRAMER DARYL			Lab Number: 12 1					6	1	DNR NO: 120- 158	1	7		INV NO:	H	C	CNTY: 041 1985	339	#	
File ID: 32N17E08AAB	074150	Owner: ANDERSON RALPH W.			Lab Number: 10 7					48	3	DNR NO: -	2			INV NO:	S	D	CNTY: 041 1950		#	3
File ID: 32N17E10AA	074152	Owner: HANSON VICTOR			Lab Number: 5 1					7	1	DNR NO: 120- 175	1	7		INV NO:	S	C	CNTY: 041 1961	046	#	2
File ID: 32N17E17DD	074153	Owner: HANSON VICTOR			Lab Number: 2 1					7	1	DNR NO: 100- 250	1	70		INV NO:	S	C	CNTY: 041 1961	046	#	0
File ID: 32N17E23AAAB	074154	Owner: MONTANA POWER CO.			Lab Number: 5 7	2850	1			4	1	DNR NO: 589- 599	1	75		INV NO: 78I00346 211JDRV	HN	Z	CNTY: 041 1962	120	#	2
File ID: 32N17E23CAC	074292	Owner: KRAFT LEO			Lab Number: 15 1					6	1	DNR NO: -	1	2		INV NO:	S	C	CNTY: 041 1964	015	#	0
File ID: 32N17E24BBBB	074155	Owner: HAUGEN CLIFFORD			Lab Number: 1 1	2350	2			4	1	DNR NO: 115- 125 155- 170	1	145		INV NO:	H	C	CNTY: 041 1962	021	#	0
File ID: 32N17E26DAA ?	007980	Owner: DAVEY ROBERT			Lab Number: 10 1					6	1	DNR NO: 35- 50	1	507		INV NO:	Q	C	CNTY: 041 1985	339	#	0
File ID: 32N17E26DAA ?	007981	Owner: DAVEY ROBERT			Lab Number: 8 2					6	1	DNR NO: 28- 38 42- 51	1	0		INV NO:	S	C	CNTY: 041 1985	339	#	0
File ID: 32N17E35	044246	Owner: DAVEY ROBERT A			Lab Number: 1 7					-	3	DNR NO: -	2			INV NO:	Q	Z	CNTY: 041		#	
File ID: 32N17E35CAB	074156	Owner: DAVEY ROBERT A. +		3	Lab Number: 3 6					5	1	DNR NO: 30- 65	1	7		INV NO:	Q	C	CNTY: 041 1981	046	#	1

Appendix B

On-Site Well Logs

HAVRE Form No. 603 R10/79 005 32N 17E 01 AD File No. Blaine

WELL LOG REPORT

State law requires that this form be filed by the water well driller within 60 days after comp

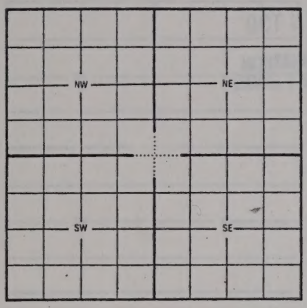
040425

11-2-84

1. WELL OWNER
Name UNIFIED DISPOSAL BOARD

2. CURRENT MAILING ADDRESS
HILL COUNTY COURTHOUSE
HAVRE, MONTANA

3. WELL LOCATION



S½ of SE ¼ NE ¼ Section 1
Township 32 (N)S Range 17 E/W
County BLAINE
Lot ____ Block ____
Subdivision ____
Well Elevation ____
Accuracy: ____ ± 10'; ____ ± 50'; ____ ± 100';

4. DRILLING METHOD ____ cable, ____ bored, ____ forward rotary, ____ reverse rotary, ____ jetted, X other (specify) COMBINATION AIR ROTARY / CABLE TOOL RIG

5. WELL CONSTRUCTION AND COMPLETION

Size of drilled hole	Size and weight of casing	From (feet)	To (feet)	Perforations X and/or Screen
6¾		0	50	
	4½" O.D 1.88 WALL GAL IRONIZED STEEL	1½ FT ABOVE GROUND	42	
	4½" O.D PVC SCH 40	4	50	

Kind Size	From (feet)	To (feet)
3/16" DRILLED	30	49

Was casing left open end? X Yes ____ No
Was a packer or seal used? X Yes AT 29½ FT No
If so, what material PLASTIC
Was the well gravel packed? ____ Yes X No
Was the well grouted? X Yes ____ No
To what depth? SURFACE TO 6 FT WITH CEMENT, 6 TO 23 WITH
Material used in grouting BENTONITE + 23 TO 29½ WITH CEMENT
Well head completion: Pitless adapter NONE
12 in. above grade X, other X
(if other, specify) CAP
Pump horsepower NONE, pump type ____
Pump intake level ____ feet below land surface
Power (electric, diesel, etc.) ____

6. WATER LEVEL
Static water level ____ feet below land surface
If flowing, closed-in pressure ____ psi
____ gpm flow through ____ inch pipe
Controlled by: ____ valve, ____ reducers, ____ other
(if other, specify) ____

7. WELL TEST DATA ____ pump ____ bailer ____ other
(if other, specify) ____
Pumping level below land surface:
____ ft. after ____ hrs. pumping ____ gpm
____ ft. after ____ hrs. pumping ____ gpm

8. WAS WELL PLUGGED OR ABANDONED? ____ Yes X No
If yes, how? ____

9. DATE STARTED SEPTEMBER 3, 1983
DATE COMPLETED SEPTEMBER 6, 1983

10. WELL LOG OBSERVATION WELL

Depth (ft.) From	To	Formation
0	3	SANDY SOIL
3	14	SANDY CLAY
14	19	BROWN SILT + SAND
19	30	SANDY CLAY
30	38	BROWN SAND - MOIST
38	39	SANDY GREY CLAY
39	42	GRAVELLY + SANDY STRATA
42	50	SANDY GREY CLAY

RECEIVED
OCT 31 1984
MONTANA D.N.R.C.
HAVRE FIELD OFFICE

(use separate sheet if necessary)

11. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.
OCTOBER 17, 1983 Date
HI-LINE DRILLING SERVICE Firm Name PHONE 265-4210 265-6479
1173 6TH ST. NO. HAVRE, MONTANA Address
Herbert Greiss Signature 46 License No.

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION DNRC
32 SOUTH EWING HELENA, MONTANA 59601 449-3634

DEPARTMENT COPY WL - 9718

Form No. 603 R10/79 005 32N 17E 01 AD File No. Blaine

HAVRE

WELL LOG REPORT

State law requires that this form be filed by the water well driller within 60 days after comp 040426

11-2-84

1. WELL OWNER
Name UNIFIED DISPOSAL BOARD

2. CURRENT MAILING ADDRESS
HILL COUNTY COURTHOUSE
HAVRE, MONTANA

3. WELL LOCATION

RECEIVED
OCT 31 1984
MONTANA D.N.R.C.
HAVRE FIELD OFFICE

NW NE SW SE

N½ SE ¼ NE ¼ Section 1
Township 32 (N)S Range 17 E/W
County BLAINE
Lot Block
Subdivision
Well Elevation
Accuracy: ± 10'; ± 50'; ± 100';

4. DRILLING METHOD cable, bored, forward rotary, reverse rotary, jetted, X other (specify) COMBINATION AIR ROTARY / CABLE TOOL RIG

5. WELL CONSTRUCTION AND COMPLETION

Size of drilled hole	Size and weight of casing	From (feet)	To (feet)	Perforations X and/or Screen
8 5/8"		0	90	Kind Size: 3/16" DRILLED; From (feet): 71; To (feet): 89
	6 5/8" O.D 250 WALL STEEL	4 FEET ABOVE ORIGINAL GROUND LEVEL	16	
	6 5/8" O.D 200# PVC	15½	90	

Was casing left open end? X Yes No
Was a packer or seal used? X Yes AT 70FT No
If so, what material PLASTIC
Was the well gravel packed? Yes X No
Was the well grouted? X Yes No
To what depth? 1470 CRUSHED GRAVEL ABOVE PACKER
Material used in grouting CEMENT SLUR
Well head completion: Pitless adapter DICKENS 1"
12 in. above grade X, other X
(if other, specify) WELL CAP
Pump horsepower 1½, pump type SUBMERSIBLE
Pump intake level 85 feet below land surface
Power (electric, diesel, etc.) ELECTRIC

6. WATER LEVEL
Static water level 40 Ft FROM TOP OF CASING feet below land surface
If flowing, closed-in pressure psi
gpm flow through inch pipe
Controlled by: valve, reducers, other
(if other, specify)

WELL TEST DATA pump X bailer other
(if other, specify)
Pumping level below land surface BAILING
88 ft. after 2 hrs. pumping 2 gpm
85 ft. after 2 hrs. pumping 2 gpm

8. WAS WELL PLUGGED OR ABANDONED? Yes X No
If yes, how?

9. DATE STARTED SEPTEMBER 1, 1983
DATE COMPLETED SEPTEMBER 3, 1983

10. WELL LOG

Depth (ft.) From	To	Formation
0	1	SOIL
1	12	GREY CLAY - TIGHT
12	20	SANDY GREY CLAY
20	25	GREY CLAY
25	26	DRY GRAVEL
26	29	GREY SHALE (JUDITH RIVER FORMATION)
29	31	BROWN SANDSTONE (DRY)
31	40	GREY SHALE
40	44	BROWN SANDSTONE (DRY)
44	61	BROWN SHALE
61	67	DARK GREY SHALE
67	72	BROWN SANDSTONE
72	73	GREY SHALE
73	76	SANDY GREY SHALE
76	86	GREY SANDSTONE - WATER 2 GPM
86	90	GREY SHALE

NOTE: HOLE WAS DRILLED TO DEPTH OF 138½ FT IN QUEST OF LARGER WATER YIELD BUT TO NO AVAIL. HOLE PLUGGED WITH GRAVEL BACK TO 90 FT LEVEL AND WELL COMPLETED AT THAT DEPTH

(use separate sheet if necessary)

11. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge...
AT 70 FT.
OCTOBER 17, 1983
Date
HI-LINE DRILLING SERVICE Phone 265-4210 265-6474
Firm Name
1173 6TH ST. NO HAVRE, MONTANA
Address
Herbert Greier 46
Signature License No.

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION DNRC
32 SOUTH EWING HELENA, MONTANA 59601 449-3634

DEPARTMENT COPY

WL · 9717

Appendix C

Near-by Well Logs

#1

...of Natural Resources and Conservation

WHITE — DEPARTMENT
PINK — BUREAU
CANARY — WELL OWNER
GOLDENROD — DRILLER

WELL LOG REPORT

#1

State law requires that this form be filed by the water well driller on any water well com pleted by him on and after July 1, 1973 within sixty (60) days after completion of the we

1. WELL OWNER: Name KOA CAMP GOUNDS Address EAST OF HAVRE, MONTANA

2. WELL LOCATION: County BLAINE ; ¼ ¼ ¼, Sec. ____, Twp. ____ N-S, Rg. ____

3. PROPOSED USE: ___Domestic ___Stock X Municipal ___Industrial ___Lawn and Garden
___Irrigation ___Other (*if other, specify*) ____

4. METHOD DRILLED: X Cable ___Bored
___Forward Rotary ___Reverse Rotary
___Jetted ___Other (*if other, specify*)

5. WELL CONSTRUCTION:
Diameter of hole 6 3/4 inches. Depth 102 ft.
Casing: X Steel X Plastic ___Concrete
___Threaded X Welded ___Other (*if other, specify*)
Pipe Weight: Dia.: From: To:
19 lb/ft. 5 5/8 inches 2 feet 102 feet
18.8 lb/ft. 5½ inches 100 feet 127 feet
___lb/ft. ___inches ___feet ___feet
Was perforated pipe used? X Yes ___No
Length of pipe perforated 15 feet
Was casing left open end? X Yes ___No
Was a well screen installed? ___Yes ___No
Material ____ Dia. ___inches
(*stainless steel, bronze, etc.*)
Perforation type: ___slots 1/4 holes
Size ___ set from ___ feet to ___ feet
Size ___ set from ___ feet to ___ feet
Size ___ set from ___ feet to ___ feet
Was a packer or seal used? ___Yes ___No
If so, what material ____
Well type: ___Straight screen ___Graveled
Was the well grouted? ___Yes ___No
To what depth? ___ feet
Material used in grouting ____
Well head completion: Pitless adapter X
12" above grade ___ Other 20"
(*If other, specify*) ____
Was the well disinfected? X Yes ___No

6. WATER LEVEL:
Static water level 15 ft. below land surface
If flowing: closed-in pressure ___ psi
GPM flow ___ through ___ inch pipe
Controlled by: ___Valve ___Reducers
___Other, *specify* ____

7. WELL TEST DATA: Pump X Bailer ___Other
(*If other, specify*) ____
Pumping level below land surface:
85 ft. after 1 hrs. pumping 25 gpm
___ ft. after ___ hrs. pumping ___ gpm

8. WELL LOG: ELEV. 2461 EST.

Depth (ft.) From	To	Formation
0	40	brown clay
40	47	sand and water
47	80	grey clay
80	88	sand and water
88	101	brown shale
101	112	blue shale
112	127	sandstone and water

(*Use separate sheet if necessary*)

9. DATE STARTED: 2/11/1978

10. DATE COMPLETED: 2/15/1978

11. WAS WELL PLUGGED OR ABANDONED? ___Yes X No
If so, how ____

12. DRILLER'S CERTIFICATION:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

[illegible] DRILLING CO. 14
Driller's or Firm Name *Licensee No.*

1605 HAMER DRIVE, HAVRE, MONTANA
Address

Signed by [signature] *Date* 2/15/78

STATE OF MONTANA
Department of Natural Resources and Conservation

#2

WELL LOG REPORT #2

WHITE — DEPARTMENT
PINK — BUREAU
CANARY — WELL OWNER
GOLDENROD — DRILLER

State law requires that this form be filed by the water well driller on any water well co pleted by him on and after July 1, 1973 within sixty (60) days after completion of the we

1. WELL OWNER: Name K.C.A. Address EAST OF HAVRE, MONTANA

2. WELL LOCATION: County BLAINE; ¼ ¼ ¼, Sec. ____, Twp. N-S, Rg. ____

3. PROPOSED USE: ___Domestic ___Stock ___Municipal ___Industrial ___Lawn and Garden ___Irrigation ___Other (*if other, specify*)

4. METHOD DRILLED: X Cable ___Bored ___Forward Rotary ___Reverse Rotary ___Jetted ___Other (*if other, specify*)

5. WELL CONSTRUCTION:
Diameter of hole 6 3/4 inches. Depth 128 ft.
Casing: X Steel X Plastic ___Concrete ___Threaded X Welded ___Other (*if other, specify*)
Pipe Weight: Dia.: From: To:
___lb/ft. 6 5/8 inches 1a.g feet 96 feet
148 ft lb/ft. 5 ½ inches 96 feet 128 feet
___lb/ft. ___inches ___feet ___feet
Was perforated pipe used? X Yes ___No
Length of pipe perforated 20 feet
Was casing left open end? X Yes ___No
Was a well screen installed? ___Yes ___No
Material ___ Dia. ___inches (*stainless steel, bronze, etc.*)
Perforation type: ___slots X holes
Size 1/4 set from 108 feet to 128 feet
Size ___set from ___feet to ___feet
Size ___set from ___feet to ___feet
Was a packer or seal used? ___Yes ___No
If so, what material
Well type: ___Straight screen ___Graveled
Was the well grouted? ___Yes ___No
To what depth? ___feet
Material used in grouting
Well head completion: Pitless adapter X
12" above grade ___ Other ___
(*If other, specify*)
Was the well disinfected? X Yes ___No

6. WATER LEVEL:
Static water level 10 ft.below land surface
If flowing: closed-in pressure ___psi
GPM flow ___through ___inch pipe
Controlled by: ___Valve ___Reducers
___Other, *specify*

LL TEST DATA: ___Pump X Bailer ___Other *other, specify*)
ing level below land surface:
ft. after ___hrs. pumping ___gpm
ft. after ___hrs. pumping ___gpm

8. WELL LOG: ELEV. 2453 GR

Depth (ft.) From	To	Formation
0	34	brown clay
34	97	blue clayy
97	108	brown shale
108	128	shaly sandstone & water

(*Use separate sheet if necessary*)

9. DATE STARTED: SEPT 6 1977

10. DATE COMPLETED: SEPT 10 1977

11. WAS WELL PLUGGED OR ABANDONED? ___Yes ___
If so, how

12. DRILLER'S CERTIFICATION:
This well was drilled under my jurisdicti and this report is true to the best of my knowledge.

SIMPSON DRILLING CO. 15
Driller's or Firm Name *License No.*

1609 MAPLE DRIVE, HAVRE, MONTANA
Address

Signed by *Date*

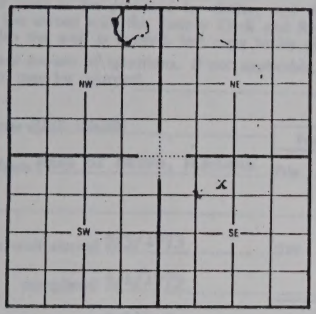
#3

Form must be filed within 30 days after completion of the well.

1. **WELL OWNER**
Name MR JOBBIE DION

2. **CURRENT MAILING ADDRESS**
JOHKAN MONTANAN

3. **WELL LOCATION**



NE ¼ NW ¼ SE ¼ Section 36
Township 33N N/S X Range 17E E/W X
County BLAINE
Lot _____ Block _____
Subdivision _____
Well Elevation 2745 est
Accuracy: ____ ± 10'; ____ ± 50'; ____ ± 100';

4. **DRILLING METHOD** ____ X cable, ____ bored, ____ forward rotary, ____ reverse rotary, ____ jetted, ____ other (specify)

5. **WELL CONSTRUCTION AND COMPLETION**

Size of drilled hole	Size and weight of casing	From (feet)	To (feet)	Perforations ____ and/or Screen ____ Kind Size	From (feet)	To (feet)
7"	6" 18#	0	35'			

Was casing left open end? X Yes ____ No
Was a packer or seal used? ____ Yes ____ No
If so, what material ____
Was the well gravel packed? ____ Yes X No
Was the well grouted? X Yes ____ No
To what depth? 18'
Material used in grouting clay
Well head completion: Pitless adaptor yes
12 in. above grade ____, other 2'
(if other, specify) ____
Pump horsepower 1/3, pump type sub
Pump intake level 26 feet below land surface
Power (electric, diesel, etc.) electric

6. **WATER LEVEL**
Static water level ____ feet below land surface
If flowing, closed-in pressure ____ psi
____ gpm flow through ____ inch pipe
Controlled by: ____ valve, ____ reducers, ____ other
(if other, specify) ____

7. **WELL TEST DATA** X pump ____ bailer ____ other
(if other, specify) ____
Pumping level below land surface:
16 ft. after 2 hrs. pumping 15 gpm
____ ft. after ____ hrs. pumping ____ gpm

8. **WAS WELL PLUGGED OR ABANDONED?** ____ Yes X No
If yes, how? ____

9. **DATE STARTED** AUG. 24-1981
DATE COMPLETED AUG. 29-1981

10. **WELL LOG**

Depth (ft.) From	To	Formation
0	12	hard grey brown clay no surface water
12	29	brown clay
29	35	gravel and water

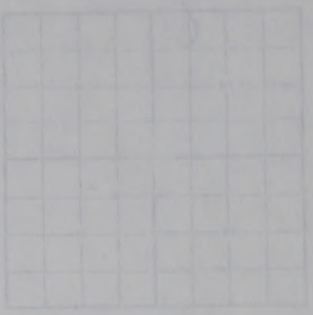
(use separate sheet if necessary)

11. **DRILLER'S CERTIFICATION**
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

Date AUG. 29-1981
Firm Name JACOBSON DRILLING CO
Address 1609 MAPLE DRIVE, HAVRE, MONTANA
Signature ____ License No. 390

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION DNRC
32 SOUTH EWING HELENA, MONTANA 59601 449-3824

WELL DRILLER COPY



STATE PUBLISHING COMPANY

County Hill

#4

STATE OF ONTANA
ADMINISTRATOR OF GROUNDWATER CODE
MONTANA WATER RESOURCES BOARD

NOTICE OF COMPLETION OF GROUNDWATER APPROPRIATION BY MEANS OF WELL

Developed after January 1, 1962

(Under Chapter 237 Montana Session Laws, 1961, as amended)

This form to be prepared by driller, and three copies to be filed by the owner with the County Clerk and Recorder in the county in which the well is located, last copy to be retained by driller.

Please answer all questions. If not applicable, so state, otherwise the form may be returned.

Owner JOHN GAUER

Address East of Havre, MOntana

Date well started 5/3/1973

completed 5/4/1973

For Administrator's Use
File
GW 1

Type of well drilled
(Dug, driven, bored or drilled)

Equipment used cable tools
(Churn drill, rotary or other)

Water Use: Domestic ☒ Municipal ☐ Stock ☐ Irrigation ☐

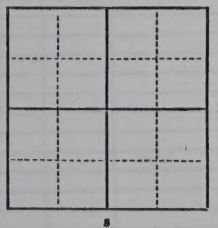
Industrial ☐ Drainage ☐ Other ☐* Garden/Lawn ☐

*Describe

USE: If used for irrigation, industrial, drainage or other. Explain, state number of acres and location or other data (i.e. Lot, Block and Addition).

ESTIMATED ANNUAL WITHDRAWAL

Size of Drilled Hole	Size and Weight of Casing	From (Feet)	To (Feet)	PERFORATIONS Kind Size	From (Feet)	To (Feet)
6 3/4	65/8 28#	18"ag	53'			
5½"	5"250	50'	105'	¼"	85'	105'



Static water level 24' ft.*
Pumping water level 55' ft.*
at 20 gallons per minute,
measured 60 minutes after pumping began.
*Measured from ground level.
Well developed by
for hours.
Power Pump HP
Remarks: (Gravel packing, cementing, packers, type of shutoff)

¼ ¼ Sec.
T. N R. E
S W

INDICATE LOCATION OF WELL AND PLACE OF USE, IF POSSIBLE.
EACH SMALL SQUARE REPRESENTS 40 ACRES.

Simpson Drilling Co.

Driller's Signature

Driller's Address 1609 Maple Drive,

Havre, Montana LICENSE NO. 15

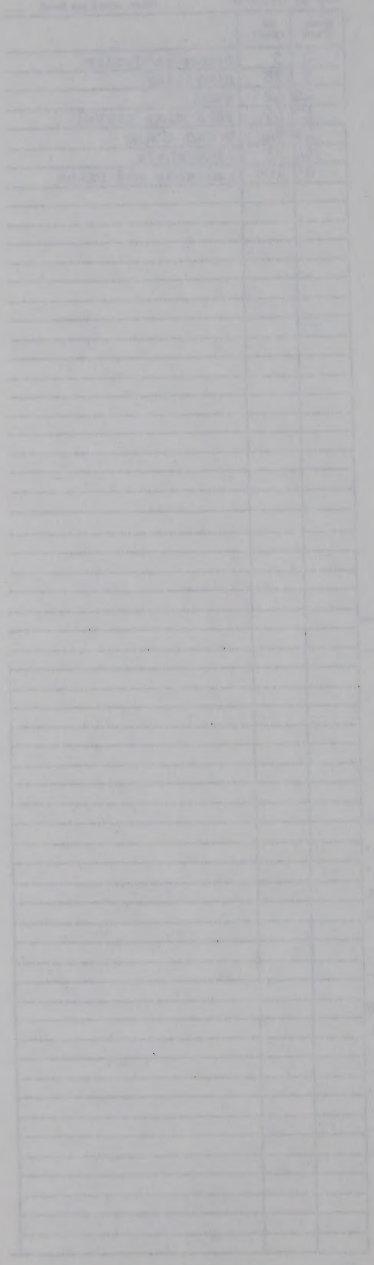
DRILLER'S LOG

Indicate the character, color, thickness of strata such as soil, clay, sand, gravel, shale, sandstone, etc. Show depth at which water is found and height to which water rises in well.

Top of Ground (Elev. above sea level)

From (Feet)	To (Feet)	
0	5	brown sandyclay
5	28	gray clay
28	42	sand
42	49	sand clay gravel
49	54	brown shale
54	85	blue shale
85	105	sandstoe and water

105 Show exact depth of bottom



Havre COS 33N 17E 36 ACC B.Sauve

Form No. 603 (R 6-87)

File No. 70934-g 40J

WELL LOG REPORT

055094

State law requires that this form be filed by the water well driller within 60 days after completion of the well.

1. **WELL OWNER**
Name Thomas Patrick

2. **CURRENT MAILING ADDRESS**
Box 396 Shambo Rte.
Havre, MT. 59501

3. **WELL LOCATION**
County BLAINE
Township 33N N/S Range 17E E/W
SW SW 1/4 NE 1/4 Section 36
Lot Block
Subdivision
Tract Number

4. **PROPOSED USE** Domestic ☐ Stock X ☐ Irrigation ☐
Other ☐ specify

5. **DRILLING METHOD** X cable, air rotary,
forward rotary, reverse rotary, jetted,
other (specify)

6. **WELL LOG**

Depth (ft.) From	To	Formation
0	10	SANDY CLAY & GRAVEL
10	23	SAND & CLAY STREAKS
23	59	STICKY GRAY CLAY
59	62	SAND & GRAVEL WATER

ATTACH ADDITIONAL SHEETS IF NECESSARY

7. **WELL CONSTRUCTION AND COMPLETION**

Size of drilled hole	Size and PSI Rating of casing	From (feet)	To (feet)
6"	6 5/8 .250 STEEL	2'ag	62

Perforations and/or Screen

Kind Size	From (feet)	To (feet)

RECEIVED
MAR 24 1989
MONTANA D.N.R.C.
HAVRE FIELD OFFICE

Was casing left open end? X Yes No
Was a packer or seal used? Yes X No
If so, what material
Was the well gravel packed? Yes X No
To what depth was the well grouted? BENTONITE CONT. FED ft
Material used in grouting WITH CASING
Well head completion: Pitless adapter
Yes X No
Top casing 18 in. or greater above grade
X Yes No

8. **WELL TEST DATA**
The pump test information request in this section is required for all wells. All depth measurements shall be from the top of the well casing unless otherwise specified.
All wells under 100 gpm must be tested for a minimum of one hour and provide the following information:
a) Air Pump X Bailer
b) Static water level immediately before testing 18 ft. If flowing; closed-in pressure
psi gpm
Controlled by: valve, reducers, other, (specify)
c) Depth at which pump is set for test 42
d) The pumping rate and means of discharge (i.e., bailing, airlift, pumping)
5 gpm
e) Maximum drawdown during the test 37 ft
f) Duration of test: Pumping time 4 hrs
Recovery time 2 hrs
g) Recovery water level 18 ft
Amount of time after pumping recovery level water data was taken 2 hrs
Wells intended to yield 100 gpm or more shall be tested for a period of 8 hours or more. The test shall follow the development of the well, and shall be conducted continuously at a constant discharge at least as great as the intended appropriation. In addition to the above information, water level data shall be collected and recorded on the Department's "Aquifer Test Data" form included in each packet of well logs.
NOTE: All wells shall be equipped with an access port ½ inch minimum or a pressure gauge that will indicate the shut-in pressure of a flowing well. Removable caps are acceptable as access ports.

EE EV 4447 18 Sec 2023

9. **WAS WELL PLUGGED OR ABANDONED?** Yes X No
If yes, how?

10. **DATE COMPLETED** 1/26/89

11. **DRILLER/CONTRACTOR'S CERTIFICATION**
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

2/23/89
Date

Jacobson Drilling Co.
Firm Name

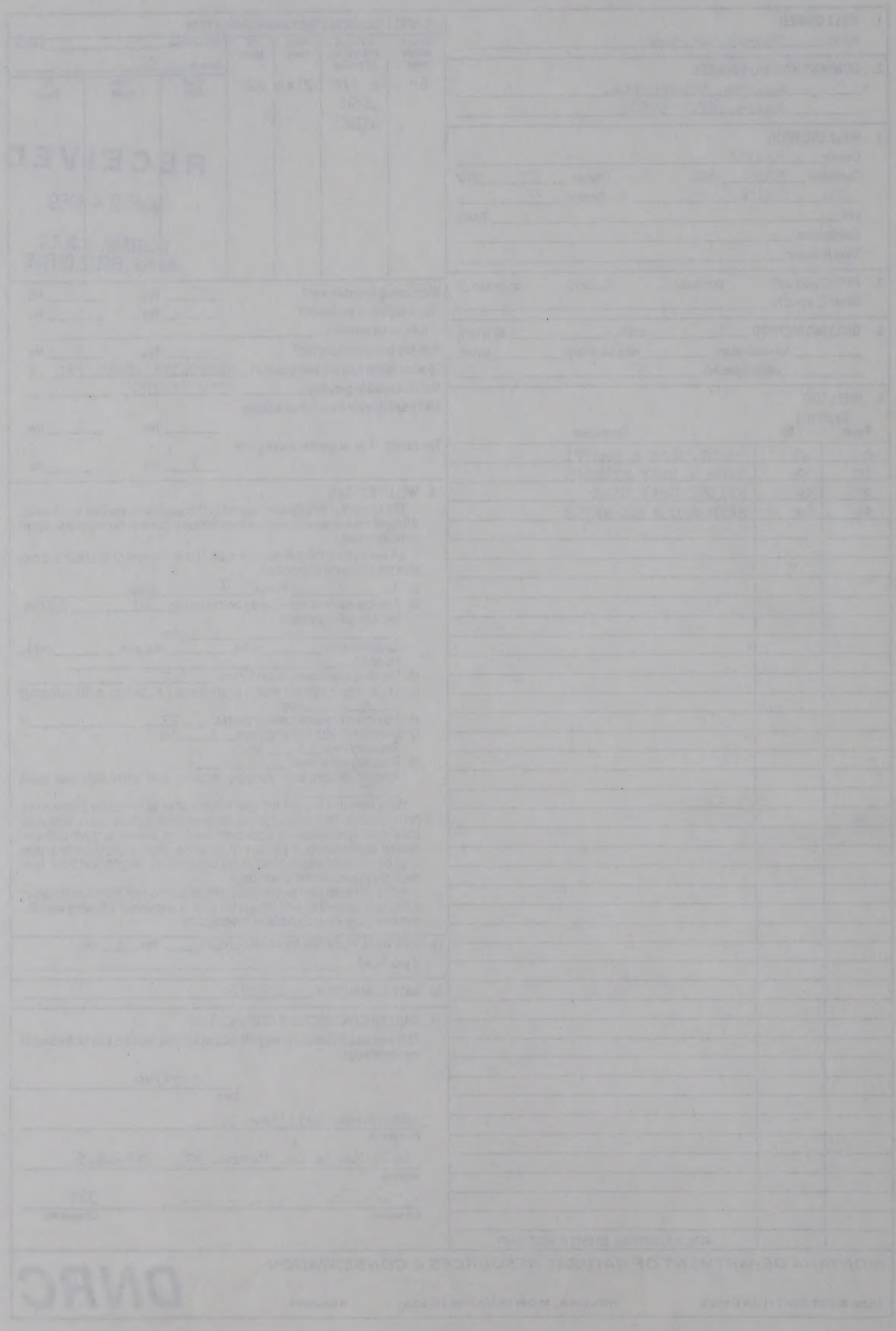
1609 Maple Dr. Havre, MT. 265-4245
Address

Signature 339
License No.

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION

1520 EAST SIXTH AVENUE HELENA, MONTANA 59620-2301 444-6610

DNRC



GW 2 005 32N 17E 01BD

Blaine

File No.

TRIPLICATE

RECEIVED
AUG 27 1963
Montana Bureau of Mines and Geology

Approved Stock Form—State Publishing Co., Helena, Montana—39318

005 T. 32 N R. 17E 1 BD

CODED

County BLAINE

STATE OF MONTANA
ADMINISTRATOR OF GROUNDWATER
OFFICE OF STATE ENGINEER

071496

Notice of Completion of Groundwater Appropriation by Means of Well

(Under Chapter 237, Montana Session Laws, 1961)

Owner GEORGE JOHNSON Address LOHMAN, MONTANA

Driller WILDE DRILLING SERVICE Address HAVRE, MONTANA

Date of Notice of Appropriation of Groundwater

Date well started AUGUST 14 1963 Date Completed AUG. 24, 1963

Type of well DRILLED (dug, driven, bored or drilled) Equipment Used CABLE TOOL RIG (Churn, drill, rotary or other)

Water Use: Domestic ☐ Municipal ☐ Other ☐ Irrigation ☐
Industrial ☐ Drainage ☐ Stock ☒

Indicate on the diagram the character and thickness of the different strata met with in drilling, such as soil, clay, shale, gravel, rock or sand, etc. Show depth at which water is encountered, thickness and character of water-bearing strata and height to which water rises in the well.

Top of Ground (Elev. above sea level)	
0	
18	SAND & SILTY BROWN CLAY
24	QUICKSAND - WATER
38	BLUE CLAY (SOFT)
45	GREY CLAY (SOFT)
62	GREY CLAY & PEBBLES
70	BROWN SANDSTONE & BRACKISH ALKALINE WATER
76	LIGHT BROWN SHALE
80	GREY SHALE
82	HARD SANDSTONE SHELL
86	BLUE SHALE
94	GREY SANDSTONE - BRACKISH ALKALINE WATER
97	BLUE SHALE
98	DARK BROWN SHALE
105	LIGHT BROWN SHALE
114	GREY SHALE
119	GREY SANDSTONE - WATER - OVER 2 G.P.M.
120	BLUE SHALE

Size of Drilled Hole	Size and Weight of Casing	From (Feet)	To (Feet)	PERFORATIONS Kind Size	From (Feet)	To (Feet)
8"	6" I.D. 13# PER FOOT	0	114	NO PERFORATIONS		

ELEV 2449
SWL 2443

Static Water Level for non-flowing Well 6 feet.

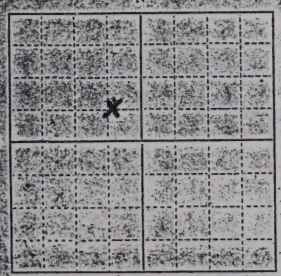
Shut-in Pressure for Flowing Well NOT APPLICABLE

Pumping Water Level 110 feet at 2 gal. per minute.

Discharge in gal. per min. of flowing well NOT APPLICABLE

How Tested BAILER Length of Test 2 HOURS

Remarks: (Gravel packing, cementing, packers, type of shutoff, location of place of use of groundwater if not at well, and any other similar pertinent information, including number of acres irrigated, if used for irrigation) CASING SET ABOVE SANDSTONE AT 114 FEET AND CEMENTED TO SEAL OFF BAD WATER. OPEN HOLE FROM 114 TO 120 FT



SE ¼ NW ¼ Sec. 7 T. 32 N R. 17E

Indicate location of well and place of use, if possible. Each small square represents 10 acres.

Show exact depth of bottom.

WATER FROM 62-90 & 96-94 FOOT VEINS HIGH IN IRON, OVER 7 PPM. WITH HARDNESS OVER 100. BITTER TASTE. PRESUMABLY HIGH IN EPSOM & GLAUBER SALTS & ALKALI

WATER FROM 114-119 MILD SODA & IRON - HARDNESS OF 3 PPM

46
Driller's License Number

Driller's Signature

This form to be prepared by driller, and three copies to be filed by the owner with the County Clerk and Recorder in the county in which the well is located.

Please answer all questions. If not applicable, so state, otherwise the form will be returned.

Original to the County Clerk and Recorder; duplicate to the State Engineer; Triplicate to the Montana Bureau of Mines and Geology and Quadruplicate for the Appropriator.

Form No. 603 (Rev. 7/76)

STATE OF MONTANA

005 33N 17E 36 DBD

Department of Natural Resources and Conservation

File No. 71336

071336

CODED

WELL LOG REPORT

BLAINE

Gold-Driller

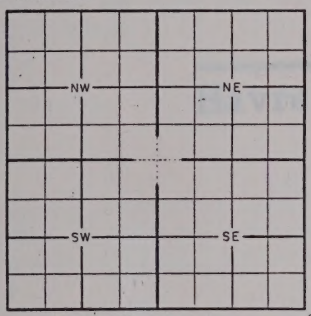
State law requires that this form be filed by the water well driller within 60 days after completion of the well, and Form 602, Notice of Completion of Groundwater Development, be filed by the well owner within 60 days after the water has been put to beneficial use.

1. WELL OWNER
Name THOMAS R. PATRICK

2. CURRENT MAILING ADDRESS
[illegible]
HAVRE, MONTANA [illegible]

3. PROPOSED USE X domestic (includes lawn and garden); X stock; _____ municipal; _____ industrial; _____ irrigation; _____ other (specify) _____

4. WELL LOCATION



¼ SE ¼ NW ¼ SE ¼ Section 36
T. 33 R. 17 (N or S) (E or W)
OR, Lot _____ Block _____
Subdivision _____
City [illegible] County BLAINE
Elevation _____ Accuracy: __ ±10'; __ ±50'; __ ±100';

5. DRILLING METHOD X cable, _____ bored, _____ forward rotary, _____ reverse rotary, _____ jetted; _____ other (specify) _____

6. WELL CONSTRUCTION AND COMPLETION

Size of drilled hole	Size and weight of casing	From (feet)	To (feet)	Perforations ___ and/or Screen ___ Kind Size	From (feet)	To (feet)
10"		0	20			
8¼"	6⅝" O.D. 280 GALL. STEEL	3 FEET ABOVE GROUND	43			
	5⅛" O.D. PVC 200	40	48	432" DRILLED STEEL [illegible]	43	48

Was casing left open end? _____ Yes, X No
Was a packer or seal used? _____ Yes, X No
If so, what material _____
Was the well gravel packed? _____ Yes, _____ No
Was the well grouted? X Yes, _____ No
To what depth? 7 SACK SHOT
Material used in grouting BENTONITE
Well head completion: Pitless adapter [illegible]
12 in. above grade X, other _____
(if other, specify) [illegible]
Pump horsepower [illegible], pump type [illegible]
Pump intake level [illegible] feet below land surface
Power (electric, diesel, etc.) [illegible]

7. WATER LEVEL
Static water level 18½ feet below land surface
If flowing, closed-in pressure _____ psi
_____ gpm flow through _____ inch pipe
Controlled by: _____ valve, _____ reducers, _____ other (if other, specify) _____

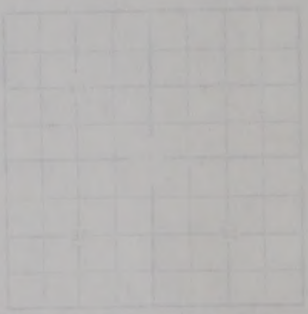
8. WELL TEST DATA X pump _____ bailer X other (if other, specify) AIR COMPRESSOR BLOW OFF
Pumping level below land surface:
[illegible] ft. after [illegible] hrs. pumping [illegible] gpm
[illegible] ft. after [illegible] hrs. pumping [illegible] gpm

9. WAS WELL PLUGGED OR ABANDONED? ___ Yes X No
If yes, how? _____

10. DATE STARTED DECEMBER 3, 1979
DATE COMPLETED DECEMBER 5, 1979

11. WELL LOG

Depth (ft.) From	To	Formation
0	3	SOIL
	50	[illegible]
	[illegible]	[illegible]
	14	[illegible]
	23	[illegible]
	28	[illegible]
	42	[illegible]
		[illegible]
	43½	[illegible]
		[illegible]
		[illegible]
	48	[illegible]
		[illegible]
		[illegible]



Appendix D

Havre Testing Labs Report

HAVRE TESTING LABS, Inc.

HIGHWAY 2 WEST
P.O. BOX 483
HAVRE, MT 59501
PH. (406) 265-1331

May 18, 1983

SUBJECT Site Investigation for the proposed Sanitary Landfill located in Sec. 1, T.32 N., R. 17 E. and Sec. 6, T. 32 N., R. 18 E.

Hill County Health and Planning
Hill County Courthouse
Havre, MT 59501

Attn: Terry Schultz

Dear Mr. Schultz,

PURPOSE

On Friday May 13, 1983 I accompanied you to the site of the proposed multi-county sanitary landfill in order to determine the existing soils stratum and to define the existance of any ground water table.

PROCEDURE

Five holes were dug with a back hoe; one on the bench immediatly to the North of the coulee, one to the South, and three in the coulee bottom itself; placed near the head, at the mid point, and at the mouth with its confluence with a secondary drainage. This final hole was dug to maximum depth in the lowest elevation of the area to determine any ground water at its most likely place. Soils were evaluated by sight and feel and classes noted along with moisture conditions.

AREA DESCRIPTION

The proposed area is situated in the Judith River Formation which is covered in this area by about twenty feet of glacial till. The fill area is in a coulee which cut through the till and exposed the underlying formation with subsequent valley fill and soil formation. The slopes are quite stable with no evidence of rapid mass wasting. Exposed Judith River Formation appears on the steeper hillsides with resultant soil creep. A sandstone shelf marks the top of the Judith River Fm. here. This shelf outcrops about half way up the bank on both the North and South sides. Difficulty would be encountered in excavating this material and should be avoided.

Excellent vegetative growth is evident throughout the area except where natural topsoil was unable to develope due to extreme slope (less than 10% of the area). Any of this material would make excellent final cover and sufficient quantities should be stockpiled for future use.

MATERIALS REMARKS

Three days prior to this site investigation, the area received over 2" of precipitation and the sandy texture of the material on the bench to the South of the coulee was evidenced by some localized seepage at the top facies of the Judith River Sandstone. I would not recommend the use of this sandy textured material located on the south bench for cover material, and I feel this seepage represents run off only through this sandy material and not a permanent exposure of the water table. The remainder of the soils encountered can be worked easily and will compact readily.

HOLE LOG

(See attached drawing for approximate hole locations.)

Hole #1

0'-1' Topsoil-Moist Organic Loam
1'-2' Moist Silty Clay Loam
2'-5' Dry Silty Loam
5'-6' Silty Clay w/stones & cobbles
6'-8'+ Silty Clay Loam

Hole #2

0'-1' Topsoil-Moist Organic Clay Loam
1'-2½' Moist Silty Loam
2½'-3' Silty Sand-Dry
3'-6' Sandy Loam
6'-7'+ Blue-Grey Clay

Hole #3

0'-1' Topsoil-Moist Silty Clay Loam
1'-2' Moist Silty Clay Loam
2'-4' Silty Loam-Moist
4'-7'+ Silty Clay-Moist

Hole #4

0'-1' Topsoil-Moist Silty Clay Loam
1'-3' Silty Clay Loam-Moist
3'-7'+ Dry Silty Loam

Hole #5

0'-12' Silty Clay Loam-Dry
No water table was encountered in this hole

Let me know if I may be of any further assistance.

Thank you.

Very truly yours,
Havre Testing Labs, Inc.

By Raleigh J. Nordhagen
Raleigh J. Nordhagen, Mgr.

MATERIALS REMARKS

There days prior to this site investigation, the area received over 2" of precipitation and the sandy texture of the material on the bench to the South of the roadcut was evidenced by some localized seepage at the top facies of the Mowry River Formations. I would not recommend the use of this sandy textured material located on the south bench for cover material, and I feel this seepage phenomenon was caused only through this sandy material and not a permanent exposure of the water table. The remainder of the soils encountered can be worked easily and will compact readily.

HOLE LOG

(See attached drawing for approximate hole locations.)

Hole #1

0'-2'	Topsoil-Moist Organic Loam
2'-5'	Moist Silty Clay Loam
5'-8'	Dry Silty Loam
8'-8½'	Silty Clay w/stones & cobbles
8½'+	Silty Clay Loam

Hole #2

0'-1'	Topsoil-Moist Organic Clay Loam
1'-2½'	Moist Silty Clay Loam
2½'-3'	Moist Silty Sand-Dry
3'-8'	Sandy Loam
8'-7'+	Blue-Grey Clay

Hole #3

0'-1'	Topsoil-Moist Silty Clay Loam
1'-2'	Moist Silty Clay Loam
2'-4'	Silty Loam-Moist
4'-7½'	Silty Clay-Moist

Hole #4

0'-1'	Topsoil-Moist Silty Clay Loam
1'-3'	Silty Clay Loam-Moist
3'-7½'	Dry Silty Loam

Hole #5

0'-12' Silty Clay Loam-Dry

No water table was encountered in this hole

Let me know if I may be of any further assistance.

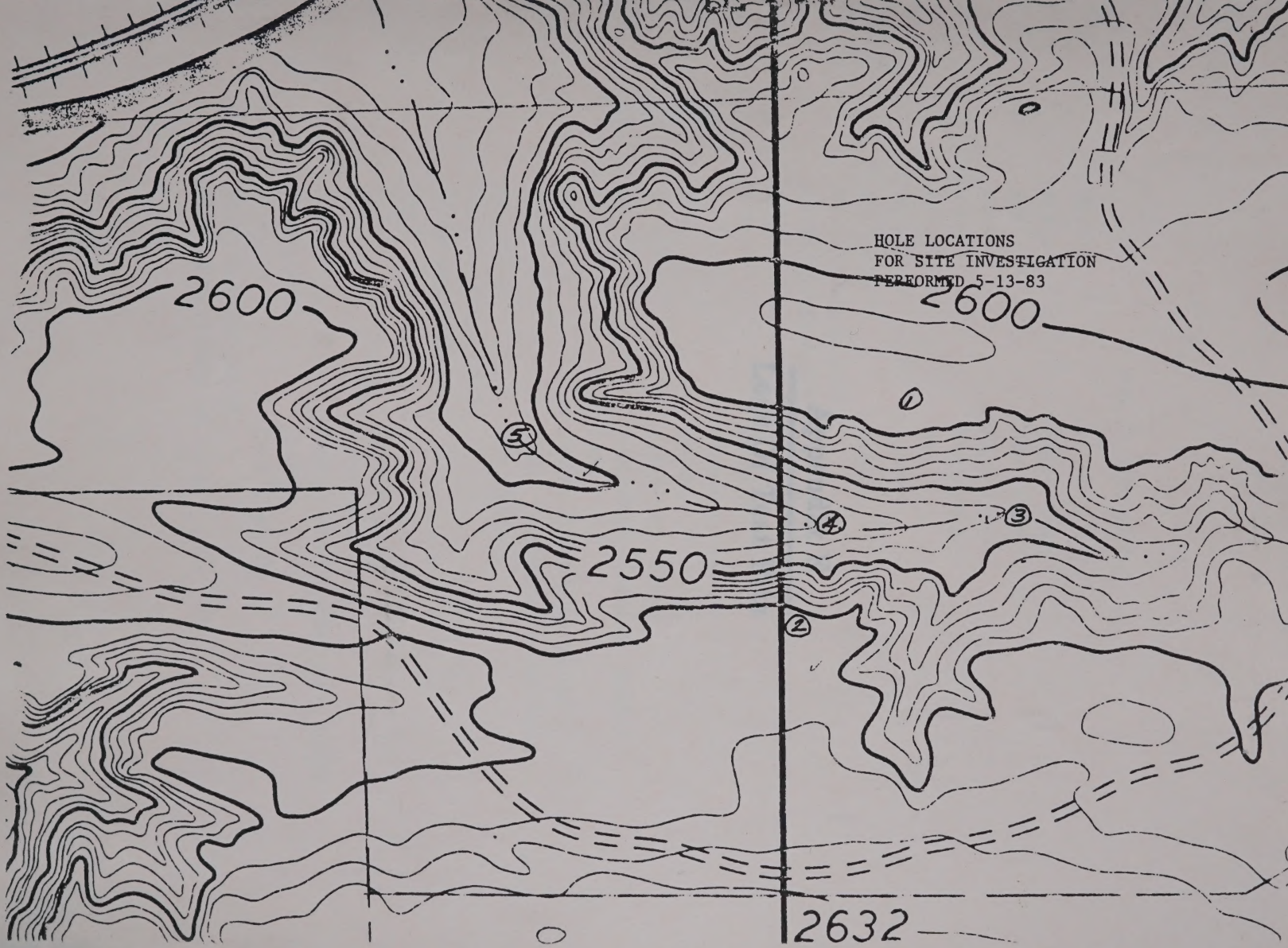
Thank you.

Very truly yours,

Dawn Testing Labs, Inc.

By _____

Patricia D. McCampen, Mgr.


HOLE LOCATIONS
FOR SITE INVESTIGATION
PERFORMED 5-13-83
2600
2600
2550
2632
1
2
3
4
5

Appendix E

Logs Of Test Pits

LOG OF TEST PITS

TP-1

0-4.6'	BLACK CLAY
4.6'-7'	MED. CLAY
7'-9'	GRAY CLAY
9'-11'	FRACTURED
11'-12.7'	RED
12.7'-15'	LIGHT
15'-17.6'	COAL

17.6' = TOTAL DEPTH

WATER ENCOUNTERED AT 15'

TP-2

0-2.5'	TOPSOIL
2.5'-5'	GRAVELLY CLAY
5'-7'	GRAVEL
7'-10'	CLAYSTONE, OLIVE
10'-11'	SILTSTONE, REDDISH, ORANGE
11'-12'	COAL
12'-13.5'	CLAYEY SILTSTONE, BROWN
13.5'-16'	SANDY SILTSTONE, LIGHT GRAY
16'-19.5'	TAN MIXTURE

19.5' = TOTAL DEPTH

WATER ENCOUNTERED AT 11.5'

TP-3

0-2'	TOPSOIL
2'-6'	LOESS/SAND
6'-11.7'	POORLY GRADED SAND (SP), BROWN
11.7'-12.5'	CLAY
12.5'-19.5'	SAND & GRAVEL

19.5' = TOTAL DEPTH

WATER ENCOUNTERED AT 12.5'

TP-4

0-2.5'	SILT CALICHE, WHITE
2.5'-5.5'	LEAN CLAY (CL), BROWN
5.5'-7.3'	SILTY SAND (SM), BROWN
7.3'-10'	SILTSTONE, ORANGE
10-'12.5'	SAND & CLAY
12.5'-19'	CLAY

19' = TOTAL DEPTH

WATER ENCOUNTERED AT 13.5'

TP-5

0-3'	GRAVEL
3'-12'	FAT CLAY (CH), GRAYISH BROWN
12'-16.5'	SILTSTONE & CLAYSTONE, DARK GRAYISH BROWN TO VERY DARK GRAYISH BROWN (B+D+E)
16.5'-19'	CLAYSTONE TO SILTY CLAYSTONE, GRAY TO GRAYISH BROWN (A+C)

19' = TOTAL DEPTH

NO WATER INDICATED

TP-6

0-3'	SILTY CLAY (CL/ML) REDDISH BROWN (D)
3'-5'	CLAYISH GRAVEL
5'-9'	GRAVEL
9'-14.5'	SILTY CLAYSTONE, OLIVE (C)
14.5'-18.5'	CLAYSTONE, BLACK (B)
18.5'-19.5'	SILTY CLAYSTONE, DARK BLUISH GRAY (A)

19.5' = TOTAL DEPTH

WATER ENCOUNTERED AT 9'

TP-7

0'-5'	GRAVEL
5'-7.8'	GRAVELLY, RUBBLY CLAY
7.8'-12.5'	BLUE SHALE
12.5'-13'	SILTY SANDSTONE, BLACK (A)

13' = TOTAL DEPTH

WATER ENCOUNTERED AT 7.8'

TP-8

0'-2'	TOPSOIL
2'-3.7'	GRAVEL
3.7'-6.8'	SILTY CLAY (CL/ML) DARK BROWN (F)
6.8'-7.5'	CLAYSTONE, BROWNISH YELLOW (E)
7.5'-9'	SHALE, VERY DARK BROWN TO BLACK (C)
9'-13.7'	SHALE, OLIVE TO BLACK TO BROWNISH YELLOW (B+D+G)
13.7'-15.8'	SHALE, GRAY (A)
15.8'-18.7'	SILTSTONE, LIGHT REDDISH BROWN (H)

18.7' = TOTAL DEPTH

WATER ENCOUNTERED AT 6.8'

TP-9

0-1.5'	LEAN CLAY (CL), DARK BROWN (C)
1.5'-4'	SAND
4'-5'	GRAVEL LENSE
5'-6'	SAND
6'-8.7'	SHALE, OLIVE TO DARK OLIVE (B)
8.7'-18'	SILTSTONE, LIGHT OLIVE GRAY, (A)

18' = TOTAL DEPTH

NO WATER INDICATED

TP-10

0.-2.6'	TOPSOIL
2.6'-5.1'	LOESS CLAY
5.1'-7.9'	GRAVEL
7.9'-9.7'	GRAY CLAY
9.7'-11.5'	REDROCK CLAY
11.5'-14'	GRAY-TAN CLAY
14'-15'	COAL
15'-20'	ORGANIC CLAY THIN TAN HEAVY CLAY

20' = TOTAL DEPTH

WATER ENCOUNTERED AT 5.1'

TP-11

0-1'	TOPSOIL
1'-3'	SILT (ML), LIGHT GRAYISH BROWN, (A)
3'-9.2'	SANDSTONE, LIGHT GRAY (C)
9.2'-10.3'	GRAY CLAY
10.3'-12'	SANDSTONE, ORANGE-BROWN (D)
12'-19'	SHALE, VERY DARK BROWN (B)

19'= TOTAL DEPTH

NO WATER INDICATED

TP-12

0-1.5'	TOPSOIL
1.5'-4.5'	LOESS SILT
4.5'-9'	SANDY GRAVEL - SOME SILT
9'-11'	CLAY, SHELLS
11'-13'	FOSSIL CONGLOMERATE (A)
13'-16.5'	SILTY CLAYSTONE, OLIVE GRAY (B)

16.5-17.5 = TOTAL DEPTH

NO WATER INDICATED

TP-13

0-1.5'	TOPSOIL
1.5'-3.5'	BLACK
3.5'-5.5'	DARK BROWN
5.5'-7.5'	LIGHT FRACTURED CLAY
7.5'-14.5'	HARDER REDDISH CLAY
14.5'-18'	LIGHTER CLAY, SOME RED

18' = TOTAL DEPTH

NO WATER INDICATED

TP-14

0-2'	TOPSOIL
2'-3'	WHITE
3'-6.5'	SILTY SAND, BROWN TO LT. BROWN (C)
6.5'-10'	RED ORGANIC CLAY W/SOME COAL
10'-11.5'	COAL, BLACK (B)
11.5'-13'	LIGHTER CLAY
13'-16.5'	LEAN CLAY (CL), VERY DARK BROWN
16.5'-19'	CLAY SHALE, OLIVE GRAY (A)

19' = TOTAL DEPTH

WATER ENCOUNTERED AT 10' & 13'

TP-15

0-2.5'	TOPSOIL
2.5'-4.5'	WHITE ORGANIC
4.5'-5.5'	BLACK COAL
5.5'-8'	RED ROCK
8'-13'	LEAN TO FAT CLAY (CL/ML), (C)
13'-14'	RED ROCK WITH COAL
14'-18'	SHALE, DARK REDDISH BROWN, (A)

18' = TOTAL DEPTH

NO WATER INDICATED

TP-16

0-0.5'	TOPSOIL
0.5'-5'	CLAYSTONE, LIGHT OLIVE (D)
5'-7.5'	CLAYSTONE, BROWN (C)
7.5'-9.6'	CLAYSTONE, BROWNISH OLIVE (B)
9.6'-17'	CLAYEY SILTSTONE, DARK OLIVE (A)

17' = TOTAL DEPTH

NO WATER INDICATED

TP-17

0-1.5'	TOPSOIL
1.5'-7'	MEDIUM CLAY
7'-10'	SILTSTONE, ORANGE BROWN (B)
10'-18'	SANDSTONE, OLIVE GRAY (A)

18' = TOTAL DEPTH

WATER ENCOUNTERED AT 7'

TP-18

0-2'	TOPSOIL
2'-21'	CLAY, SANDY

21' = TOTAL DEPTH

NO WATER INDICATED

TP-19

0-2'	TOPSOIL
2'-4'	SILTY SAND (SM), LIGHT GRAYISH BROWN (A)
4'-19'	SANDY SILT TO LEAN CLAY (ML/CL) (B)

19' = TOTAL DEPTH

NO WATER INDICATED

TP-20

0-3'	TOPSOIL
3'-6'	FAT CLAY (CH), (B)
6'-18.5'	SANDY SILT (ML), (A)

18.5' = TOTAL DEPTH

NO WATER INDICATED

TP-21

0-2'	TOPSOIL
2'-4.5'	SILT (ML), VERY LIGHT BROWN (B)
4.5'-5.5'	SAND
5.5'-18'	SILTY CLAY (CL/ML), (A)

18' = TOTAL DEPTH

NO WATER INDICATED

TP-22

0'-2.5'	TOPSOIL
2.5'-4.5'	LOAM CLAY
4.5'-19'	SILTY SAND (SM)

19' = TOTAL DEPTH

NO WATER INDICATED

TP-23

0-2'	TOPSOIL
2'-3.5'	GRAVEL-DRY
3.5'-4.5'	SILT CALICHE (A)
4.5'-6'	DARK CLAY
6'-8'	SILTY SAND (SM) (C)
8'-20'	SANDY SILTSTONE (B)

20' = TOTAL DEPTH

NO WATER INDICATED

TP-24

0-2'	TOPSOIL
2'-4'	WHITE
4'-9'	CLAY
9'-11.5'	SANDY CLAY
11.5'-18'	CLAY

18' = TOTAL DEPTH

NO WATER INDICATED

TP-25

0-1.5'	TOPSOIL
1.5'-3.5'	SILTY CLAY (CL/ML) (C)
3.5'-6.5'	SILTSTONE, GRAYISH RED (D)
6.5'-7.5'	SANDSTONE, GRAY (A)
7.5'-18.5'	SANDSTONE (B)

18.5' = TOTAL DEPTH

NO WATER INDICATED

TP-26

0-2.5'	TOPSOIL
2.5'-5'	BLACK CLAY
5'-7'	WHITE SOIL
7'-9'	ROCKY CLAY
9'-19'	CLAY

19' = TOTAL DEPTH

NO WATER INDICATED

TP-27

0-3'	TOPSOIL
3'6'	SILTY SAND (SM) (A)
6'-20'	CLAYEY SAND (SC) (B)

20' = TOTAL DEPTH

WATER ENCOUNTERED AT 17.5'

TP-28

0-1'	TOPSOIL
1'-7'	FAT CLAY (CH) AND FAT SILTY CLAY (CH/MH) (A+B)
7'9'	SILTY SAND (SM), ORANGE-BROWN (F)
9'-15.7'	SILTSTONE AND SHALE (C+D)
15.7'-16'	SILTSTONE, DARK BLUE GRAY (E)

16' = TOTAL DEPTH

WATER ENCOUNTERED AT 9'

TP-29

0-1'	TOPSOIL
1'-2'	GRAVEL, SOME RED CLAY
2'-10'	MUDDY CLAY, BROWN
10'-15.5'	SHALE, DARK GRAY

15.5' = TOTAL DEPTH

WATER ENCOUNTERED AT 15.5'

TP-30

0-3'	TOPSOIL
3'-17'	CLAY

17'= TOTAL DEPTH

NO WATER INDICATED

TP-31

0-1'	TOPSOIL
1'-1.5'	BROWN SILTY CLAY W/CALICHE
1.5'-3.5'	LIGHT BROWN SILT
3.5'-4.5'	BLACK SILTY CLAY W/SS BOULDERS
4.5'-8'	OLIVE BROWN SILT SHALE
8'-10'	DARK GRAY SILTY CLAY SHALE
10'-10.5'	BROWN SANDSTONE
10.5'-13'	DARK BROWN CLAY SHALE
13'-17.5'	COAL TO SILT SHALE
17.5'-18'	LIGHT BROWN CLAYSTONE

18' = TOTAL DEPTH

WATER ENCOUNTERED AT 17.5'

TP-32

0-1.5'	TOPSOIL
1.5'-12'	SAND (SP) LIGHT BROWN
12'-16'	CLAYSTONE, DARK GRAY
16'-17'	SILTY SANDSTONE, GRAY

17' = TOTAL DEPTH

NO WATER INDICATED

TP-33

0-1.5'	TOPSOIL
1.5'-5.5'	SILT, LIGHT BROWN
5.5'-7.5'	SAND, (SP) SALT & PEPPER GRAY
7.5'-9'	CLAY SHALE, GRAY
9'-15'	SHALE, MEDIUM BROWN
15'-15.5'	SANDY SILTSTONE, GRAY

15.5' = TOTAL DEPTH

NO WATER INDICATED

Appendix F

Logs Of Test Borings

LOG OF BORING TB-1

Drilling Method: ROTARY
Fluid: AIR
Sampler: CUTTINGS
Driller: HICKEL & TOOKE

Bit: 5 7/8-INCH DRAG BIT
Drilled: 10/23/89
Plugged: 10/26/89

Depth	Description	Groundwater
	BROWN SANDY SILT	
5	SAND AND GRAVEL, Moist	
10		
15	VERY DARK BROWN SILT SHALE AND GRAYISH BLUE CLAY SHALE, Moist	
20		
25	GRAYISH BLUE SILT SHALE, Moist	
30	GRAY SANDSTONE, Medium Grained, Silty, Moist	
35	BROWN SILTSTONE, Damp	
	GRAY SILTSTONE, Damp	
40	BROWNISH GRAY SILT SHALE, Damp	
45		
50	GRAY SANDSTONE, Medium Grained, Wet	
55		10-26-89 ▽
60	WHITE FOSSIL SHELLS At 60 Ft.	9 a.m. 10-24-89 ▽
	BROWNISH GRAY SHALE, Moist	
	GRAY SANDY SHALE, Moist	
65	BROWN SHALE, Moist	
	GRAY SANDY SHALE, Moist	
	GRAY SILT SHALE, Moist	
70		5 p.m. 10-23-89 ▽
	GRAY SILT SHALE, Dry, Very Hard	▽
75	Total Depth Drilled 75 Ft.	Trace of Water Immediately Following Drilling. 12 p.m. 10-23-89
80		
85		
90		
95		
100		

Unified Disposal District
Sanitary Landfill

Damschen & Associates, Inc.
CONSULTING ENGINEERS HELENA, MONTANA

Log Of Boring
TB-1

LOG OF BORING TB-2

Drilling Method: ROTARY
Fluid: AIR
Sampler: CUTTINGS
Driller: HICKEL & TOOKE

Bit: 5 7/8-INCH DRAG BIT
Drilled: 10/23/89
Plugged: 10/26/89

Depth	Description	Groundwater
	SANDY SILT	
5	SAND Medium Grained, Moist to Wet	
10	BROWN SILTSTONE	1¼ gpm at 10' Set Casing to 17½ ft.
15		
20	DARK BROWN SILTSTONE	
25		
30	GRAY SILTSTONE	
35	BLUEISH GRAY SANDSTONE, Medium Grained, Moist	
40	BROWN CLAY SHALE	
	GRAY SANDSTONE, Dry, Hard, Cemented, Fine Grained	
45	GRAY CLAY SHALE, Moist	
	BROWN CLAY SHALE, Moist	
50	GRAY CLAY SHALE, Moist	
	VERY LIGHT GRAY SILTSTONE, Hard, Dry	
55	GRAY CLAY SHALE, Moist	
	BLUEISH GRAY SANDSTONE, Med to Fine Grained, Moist	
60	GRAY CLAY SHALE	
65		
	GRAY SILTSTONE, Hard, Dry	
	GRAY TO GRAYISH BROWN CLAY SHALE	
70		10-26-89 ▽
75		5 P.M. 10-23-89 ▽ Dry Immediately After Drilling 1 p.m. 10-23-89
	Total Depth Drilled 75 Ft.	
80		
85		
90		
95		
100		

Unified Disposal District
Sanitary Landfill

D&A Damschen & Associates, Inc.
CONSULTING ENGINEERS HELENA, MONTANA

Log Of Boring
TB-2

LOG OF BORING TB-3

Drilling Method: ROTARY
Fluid: AIR
Sampler: CUTTINGS
Driller: HICKEL & TOOKE

Bit: 5 7/8-INCH DRAG BIT
Drilled: 10/23/89
Plugged: 10/26/89

Depth	Description	Groundwater
	SANDY SILT WITH GRAVEL	
5	SAND, Fine Grained, Moist	
10	BROWN CLAY SHALE, Moist	
15		
20	BROWN SILTY SANDSTONE, Moist	
25	BROWN CLAYSTONE, Moist	
30	VERY DARK BROWN CLAY SHALE, Damp	
35		
40		
45	GRAY SILTY CLAY SHALE, Damp	
50		
55	BROWN SANDY SILTSTONE, Damp	
60	GRAY SANDY SILTSTONE, Damp	
65		
	GRAY SILTSTONE, Dry, Hard	
70	GRAY SANDSTONE, Fine Grained, Moist	
	GRAYISH BROWN CLAY SHALE	
75	DARK BROWN SILTY CALY SHALE	10-26-89
	GRAY CLAY SHALE	▽
80	Total Depth Drilled 80 Ft.	Dry Immediately After Drilling on 10-23-89 and on 10-24-89
85		
90		
95		
100		

Unified Disposal District
Sanitary Landfill

Damschen & Associates, Inc.
CONSULTING ENGINEERS HELENA, MONTANA

Log Of Boring
TB-3

Log Of Boring TB-3

United Disposal District
Sanitary Landfill

LOG OF BORING MW-1

Drilling Method: ROTARY
Fluid: AIR
Sampler: CUTTINGS
Driller: HICKEL & TOOKE

Bit: 5 7/8-INCH DRAG BIT
Drilled: 10/23 and 10/24/89
Completed: 10/24/89

Depth	Description	Groundwater
	LIGHT BROWN SILTY SAND	
5	YELLOWISH BROWN SAND, Medium Grained	
10	RED SILTSTONE, Hard	
15	BROWN SILTY CLAYSTONE, Soft, Moist	
20		
25	YELLOWISH BROWN SILTY SANDSTONE TO SANDY CLAYSTONE, Moist to Wet	
30	GRAYISH BROWN CLAY SHALE	
35	VERY DARK GRAYISH BROWN SILTY CLAY SHALE	
	GRAY CLAY SHALE	
40		
45	VERY DARK GRAYISH BROWN CLAY SHALE	
50	WHITE FOSSIL SHELLS IN SHALE	
	VERY DARK GRAYISH BROWN CLAY SHALE	
55	BLUISH GRAY SANDSTONE, Med. Grained, Moist, Soft	
	GRAY SILTSTONE, Very Hard, Dry	
	BLUISH GRAY SANDSTONE, Med. Grained, Moist, Soft	
60	BLUISH GRAY SANDSTONE, Med. Grained, Dry, Very Hard, Cemented	
	BROWN SANDY SILT SHALE	
65		
	GRAY SILTSTONE	
70		
75		
	BROWN CLAY SHALE	
80		
	GRAY SILTY CLAY SHALE	
85	DARK BROWNISH GRAY SILTY CLAY SHALE	
90	GRAY CLAY SHALE	
95	BROWN CLAY SHALE	
	GRAY SANDSTONE, Med. Grained, Soft, Moist	
100	GRAY CLAY SHALE, Wet	

Unified Disposal District
Sanitary Landfill

Damschen & Associates, Inc.
CONSULTING ENGINEERS HELENA, MONTANA

Log Of Boring

MW-1

Log Of Boring

MW-1

Limited Disposal District
Sanitary Landfill

Donahue & Associates Inc.

LOG OF BORING MW-1

Drilling Method: ROTARY
Fluid: AIR
Sampler: CUTTINGS
Driller: HICKEL & TOOKE

Bit: 5 7/8-INCH DRAG BIT
Drilled: 10/23 and 10/24/89
Completed: 10/24/89

Depth	Description	Groundwater
	GRAY CLAY SHALE, Wet	
105	GRAY CLAY SHALE, Damp	
110	GRAY SILTY SANDSTONE	
	GRAY SILTY CLAY SHALE	
	GRAY SANDSTONE, Moist	
115	GRAY SILT SHALE	
	GRAY SANDSTONE, Med. Grained, Moist to Wet	
120	GRAY SANDSTONE, Hard, Cemented, Dry	
	GRAYISH BROWN SILT SHALE	
125	GRAY SANDSTONE, Soft, Moist	
	DARK GRAY SILTY CLAY SHALE	
	GRAY SILTY SANDSTONE, Moist	
130		
	GRAY SILTY CLAY SHALE	
135		
	GRAY SANDSTONE, Moist, Soft	
140		
145		
150		
	GRAY SILT SHALE, Sandy in Lenses	
155		
160		
165		
170		
	GRAY SANDSTONE, Moist	
175		
180		
	GRAY SILTY CLAY SHALE	
185		
190		
	GRAYISH BROWN SILT SHALE	
195	GRAY SILTY CLAY SHALE	
	GRAY SILTY SHALE, Very Hard	
200	GRAY SILTY SHALE, Soft	

Unified Disposal District
Sanitary Landfill

Damschen & Associates, Inc.
CONSULTING ENGINEERS HELENA, MONTANA

Log Of Boring
MW-1

continued

LOG OF BORING MW-1

Drilling Method: ROTARY
Fluid: AIR
Sampler: CUTTINGS
Driller: HICKEL & TOOKE

Bit: 5 7/8-INCH DRAG BIT
Drilled: 10/23 and 10/24/89
Completed: 10/24/89

Depth	Description	Groundwater
	GRAY SANDSTONE, Moist	
205	GRAY CLAY SHALE	
210	GRAY SANDSTONE, Moist	
	GRAY SILTY CLAY SHALE	
215	GRAY SANDSTONE, Moist	
220	GRAY SILTY SHALE	
225	GRAY SANDY SHALE	
230	GRAY SANDSTONE	
235	GRAY SILT SHALE	
240	GRAY SANDSTONE, Water	Ground Water First Encountered During Drilling 10/23/89
245		10 gpm Air-Lifted
250	GRAY SANDSTONE, Hard, Cemented	
	GRAY SILT SHALE, Hard and GRAY SANDSTONE	
255	Total Depth Drilled 254 Ft.	
260		
265		
270		
275		
280		
285		
290		
295		
300		

Unified Disposal District
Sanitary Landfill

Damschen & Associates, Inc.
CONSULTING ENGINEERS HELENA, MONTANA

Log Of Boring

MW-1

continued

Log Of Boring MW-1

United Disposal District
Sanitary Landfill

continued

LOG OF BORING MW-2

Drilling Method: ROTARY
Fluid: AIR
Sampler: CUTTINGS
Driller: HICKEL & TOOKE

Bit: 5 7/8-INCH DRAG BIT
Drilled: 10/25/89
Completed: 10/26/89

Depth	Description	Groundwater
	LIGHT BROWN SILT	
5	YELLOWISH BROWN SILTSTONE	
	REDDISH BROWN SILTSTONE	
10	BROWN CLAY SHALE	
	BLACK SILTY COAL	Ground Water Detected in Coal During Drilling on 10/25/89. Set Steel Casing to 19 Feet Est. Yield Less Than 1 gpm
15	GRAYISH BROWN CLAY SHALE	
20	BROWN SILT SHALE, TRACE SAND	
	LIGHT GRAY CLAY SHALE, Hard, Dry	
25	VERY DARK BROWN SILTY CLAY SHALE	
30	GRAY CLAY SHALE	
	BROWN CLAY SHALE	
	GRAY CLAY SHALE, Very Hard at 33-33½	
35	GRAY SANDSTONE, Med. Grained, Moist	
	BROWN CLAY SHALE	
	GRAY CLAY SHALE	
40	BROWN CLAY SHALE	
45	GRAYISH BROWN CLAY SHALE	
	GRAY SANDSTONE, Moist	
50	DARK BROWN CLAY SHALE	
	GRAY CLAY SHALE	
55	WHITE FOSSIL SHELLS IN GRAYISH BROWN SILT SHALE	
	GRAYISH BROWN SILT SHALE	
60	GRAY AND BROWN SILT SHALE	
	GRAY SILT SHALE	
65	LIGHT GRAY SILT SHALE, Very Hard	
70	BROWN CLAY SHALE	
	GRAY CLAY SHALE	
75	GRAY SANDSTONE, Moist	
80	GRAY SANDSTONE, Hard, Cemented, Dry	
	GRAY SANDSTONE, Moist, Soft	
85	WHITE FOSSIL SHELLS IN BROWN SILT SHALE	
	BROWN SILT SHALE	
90	GRAY SANDSTONE, Moist	
95	GRAY SILTY CLAY SHALE	
	BROWN CLAY SHALE	
100		

Unified Disposal District
Sanitary Landfill

Damschen & Associates, Inc.
CONSULTING ENGINEERS HELENA, MONTANA

Log Of Boring

MW-2

LOG OF BORING MW-2

Drilling Method: ROTARY
Fluid: AIR
Sampler: CUTTINGS
Driller: HICKEL & TOOKE

Bit: 5 7/8-INCH DRAG BIT
Drilled: 10/25/89
Completed: 10/26/89

Depth	Description	Groundwater
	GRAYISH BROWN CLAY SHALE	
105	GRAY SANDSTONE, Moist	
	BROWNISH GRAY SILT SHALE	
110	GRAY SANDSTONE	
115	GRAY CLAY SHALE	
	GRAYISH BROWN CLAY SHALE	
120	BROWN CLAY SHALE	
	GRAY CLAY SHALE	
125	GRAY SANDY SHALE, Hard	
130	GRAY SANDSTONE, Soft, Moist	
	GRAY SANDSTONE, Hard, Cemented, Dry	
135	GRAY SANDSTONE, Soft, Moist	
140		
145	GRAY SILT SHALE	
150	GRAYISH BROWN CLAY SHALE	
	GRAY CLAY SHALE	
	GRAY SANDSTONE, Moist	
155	GRAY CLAY SHALE	
	DARK BROWN SILT SHALE	
160		
165	GRAYISH BROWN SILT SHALE	
170		
	GRAY SILT SHALE	
175		
180		
185	BROWNISH GRAY TO GRAYISH BROWN SILT SHALE	
190		
195	GRAY SANDSTONE, Moist	
	GRAY SILT SHALE WITH WHITE FOSSIL SHELLS	
200		

Unified Disposal District
Sanitary Landfill

D&A Damschen & Associates, Inc.
CONSULTING ENGINEERS HELENA, MONTANA

Log Of Boring
MW-2

continued

LOG OF BORING MW-2

Drilling Method: ROTARY
Fluid: AIR
Sampler: CUTTINGS
Driller: HICKEL & TOOKE

Bit: 5 7/8-INCH DRAG BIT
Drilled: 10/25/89
Completed: 10/26/89

Depth	Description	Groundwater
205	GRAY CLAY SHALE	
210		
215		
220	GRAY SANDSTONE, Fine Grained, & SHALE, Moist	
225		
230	GRAY SANDSTONE, Fine Grained, Water	10/26/89 ▽
	GRAY SANDSTONE, Hard, Cemented	
235	Total Depth Drilled 235 Ft.	
240		
245		
250		
255		
260		
265		
270		
275		
280		
285		
290		
295		
300		

Unified Disposal District
Sanitary Landfill

Damschen & Associates, Inc.
CONSULTING ENGINEERS HELENA, MONTANA

Log Of Boring
MW-2

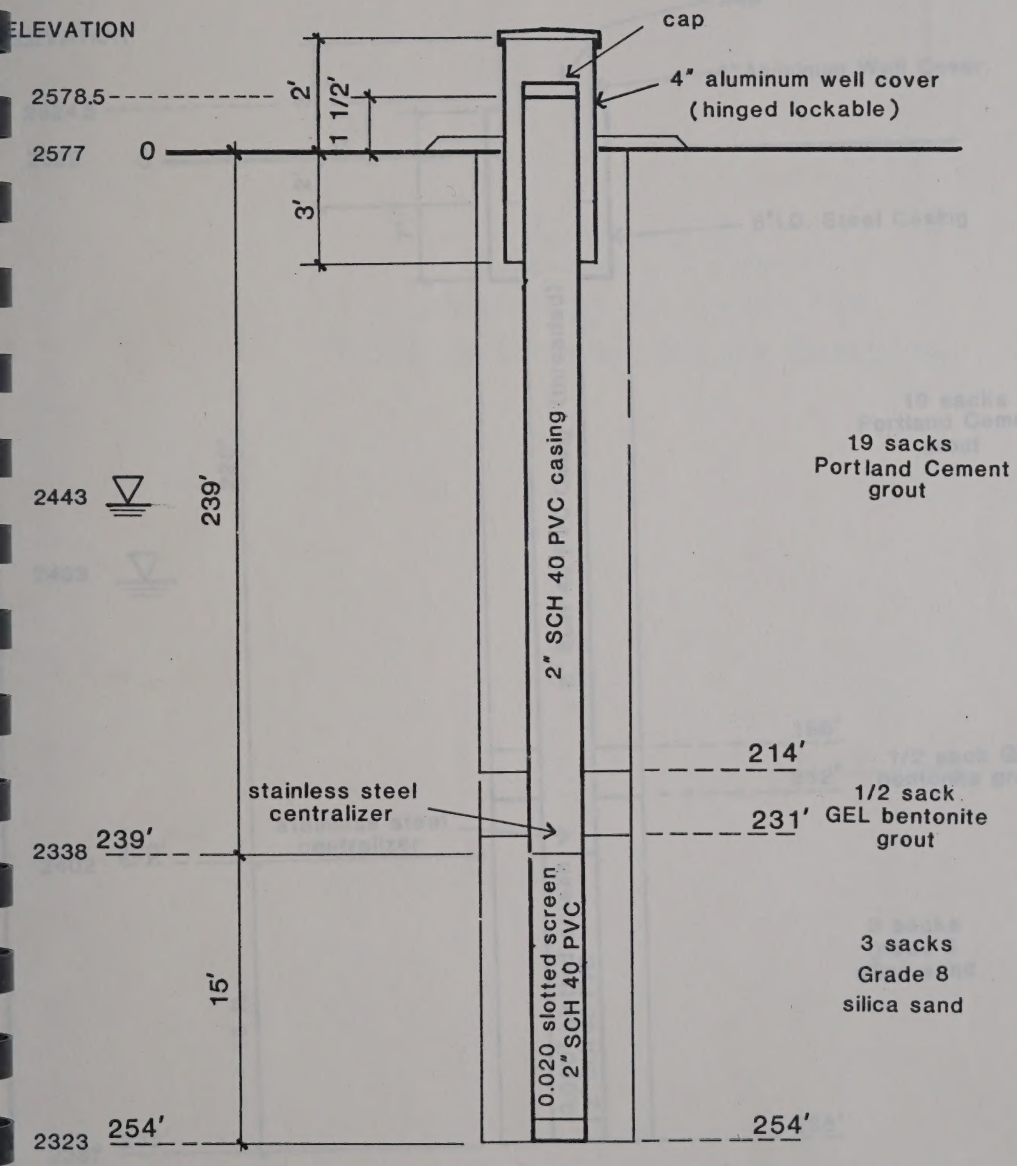
continued

Appendix G

Monitoring Well Completion Records

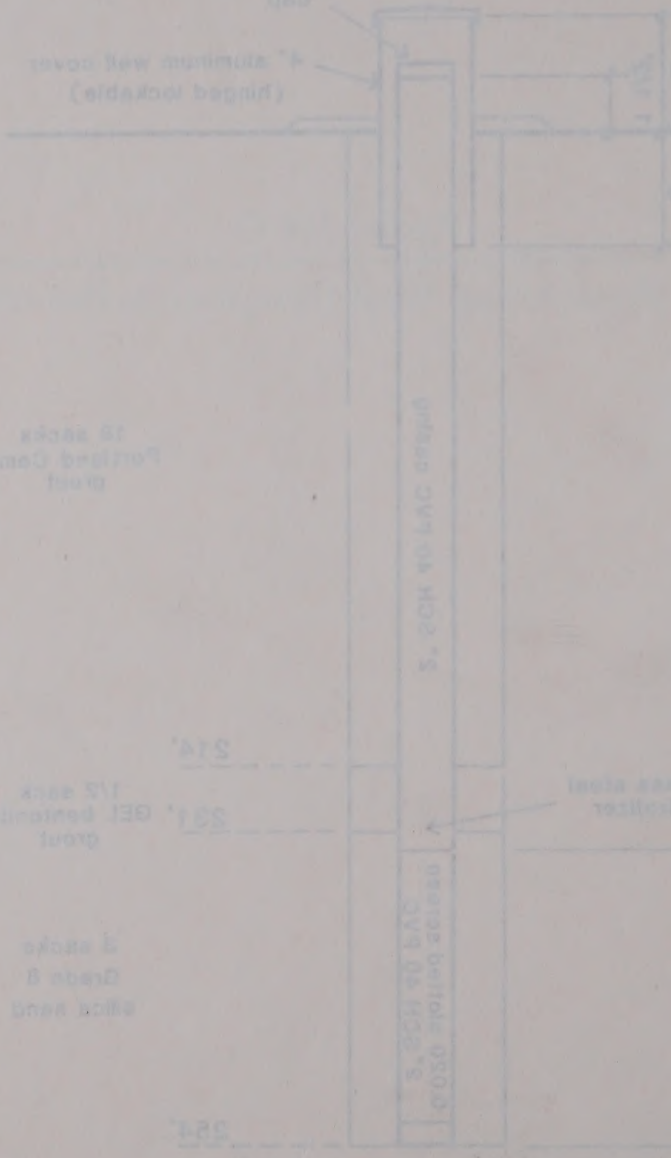
Details Of
MONITORING WELL MW-1

Unified Disposal District
Havre, Mt.

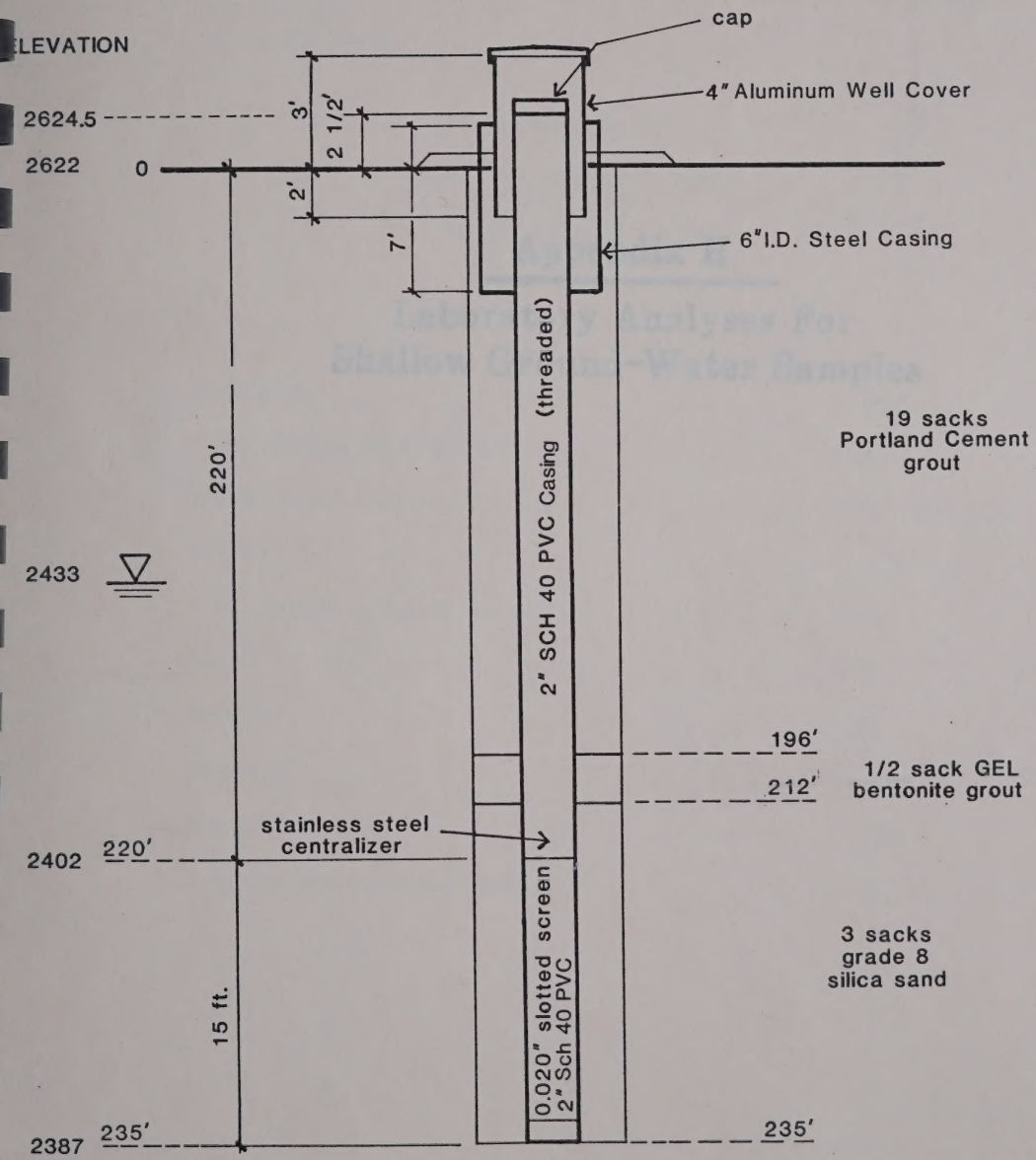


Drilled 10/23 to 10/24/89

Completed 10/24/89 By Hickel & Tooke Drilling, MWC-147

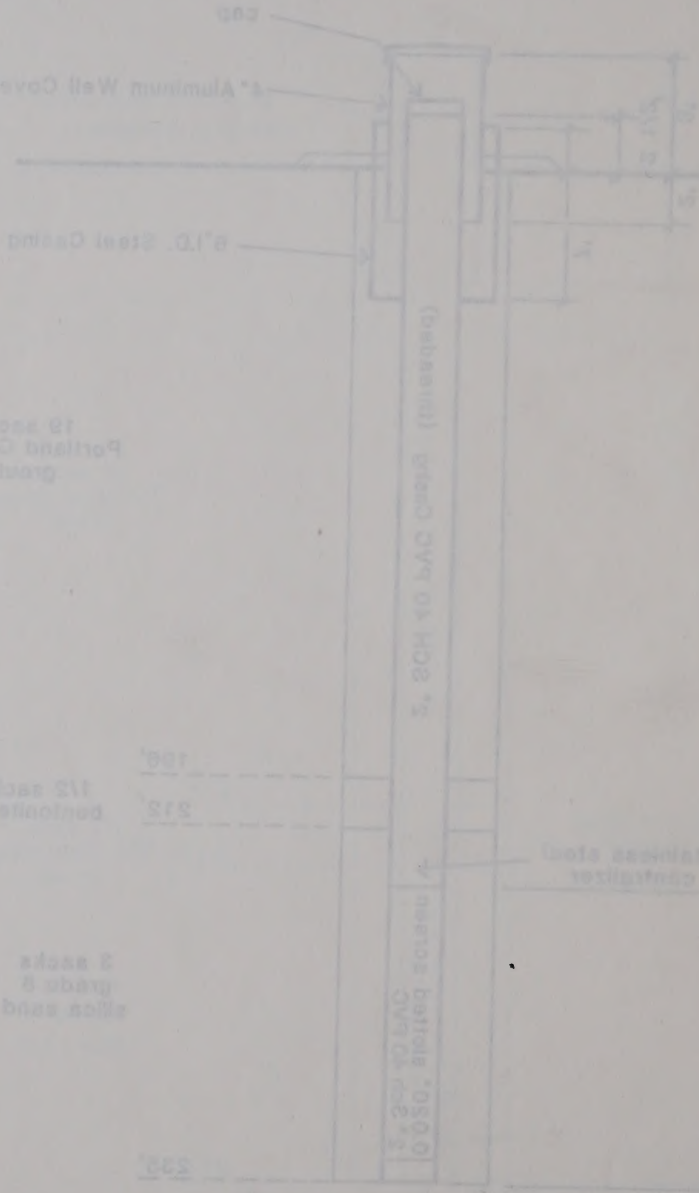


Details Of
MONITORING WELL MW-2
Unified Disposal District
Havre, Mt.



Drilled 10/25/89

Completed 10/26/89 By Hickel & Tooke Drilling, MWC-147



Appendix H

Laboratory Analyses For Shallow Ground-Water Samples

ENERGY LABORATORIES, INC.
P.O. BOX 30916 • 1107 SOUTH BROADWAY • BILLINGS, MT 59107-0916 • PHONE (406) 252-6325
800-873-5227

LABORATORY REPORT

TO: Damschen and Associates, Inc.
ADDRESS: Curt Coover
P.O. Box 4817
Helena, MT 59604

LAB NO.: 90-2200
DATE: 02/12/90 dya

upgradient

WATER ANALYSIS

Unified Disposal District - Havre
Test Pit 16
Sampled 01/23/90 @ 1200
Submitted 01/26/90

Constituent	mg/l
Total Dissolved Solids @ 180°C	13500
Specific Conductance 25°C	13300 µmhos/cm
pH, s.u.	7.5
Total Alkalinity as CaCO3	389
Sulfate	7910
Chloride	645
Chromium	<0.02
Manganese	0.03
5-Day Biochemical Oxygen Demand	7

ENERGY LABORATORIES, INC.
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800-873-5227

LABORATORY REPORT

TO: Damschen and Associates, Inc.
ADDRESS: Curt Coover
P.O. Box 4817
Helena, MT 59604

LAB NO.: 90-2201
DATE: 02/12/90 dya

WATER ANALYSIS

Unified Disposal District - Havre
Test Pit 27
Sampled 01/23/90 @ 1:00
Submitted 01/26/90

dwn gradient

Constituent	mg/l
Total Dissolved Solids @ 180°C	1570
Specific Conductance 25°C	3460 µmhos/cm
pH, s.u.	7.5
Total Alkalinity as CaCO3	2170
Sulfate	<1
Chloride	71
Chromium	<0.02
Manganese	1.81
5-Day Biochemical Oxygen Demand	160

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800-873-5227

LABORATORY REPORT

TO: Damschen and Associates, Inc.
ADDRESS: Curt Coover
P.O. Box 4817
Helena, MT 59604

LAB NO.: 90-2202
DATE: 02/12/90 dya

WATER ANALYSIS

Unified Disposal District - Havre
Observation Well
Sampled 01/23/90 @ 1:30
Submitted 01/26/90

Constituent	mg/l
Total Dissolved Solids @ 180°C	5390
Specific Conductance 25°C	6190 µmhos/cm
pH, s.u.	7.9
Total Alkalinity as CaCO3	727
Sulfate	3240
Chloride	62
Chromium	<0.02
Manganese	<0.02
5-Day Biochemical Oxygen Demand	3

Appendix I

Laboratory Analyses For Deep Ground-Water Samples

ENERGY LABORATORIES, INC.
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FAX (406) 252-6069 • 1-800-873-5227

LABORATORY REPORT

TO: Damschen & Associates
ADDRESS: Curt Coover
P.O. Box 4817
Helena, MT 59604

LAB NO.: 91-12850
DATE: 04/25/91 da

WATER ANALYSIS

Unified Disposal District
MW-2, South Side
Sampled 04/04/91 @ 4:00 p.m.
Submitted 04/10/91

Constituent	mg/l (ppm)
Potassium	5
Sodium	1620
Calcium	25
Magnesium	7
Sulfate	136
Chloride	2320
Carbonate	0
Bicarbonate	322
Total Dissolved Solids @ 180° C	3990
Total Alkalinity as CaCO3	264
pH	8.2 s.u.
Nitrate plus Nitrite as N	0.05
Ammonia as N	3.0
Chemical Oxygen Demand	43
Total Organic Carbon	<2
Total Cyanide	<0.005
Metals:	
Arsenic	0.008
Barium	0.3
Cadmium	0.003
Chromium	<0.02
Iron	0.10
Lead	0.02
Manganese	<0.02
Mercury	<0.001
Selenium	<0.005
Silver	<0.005

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LABORATORY REPORT

TO: Damschen & Associates
ADDRESS: Curt Coover
P.O. Box 4817
Helena, MT 59604

LAB NO.: 91-12850 dup
DATE: 04/25/91 da

QUALITY ASSURANCE-DUPLICATE ANALYSIS

Unified Disposal District
MW-2, South Side
Sampled 04/04/91 @ 4:00 p.m.
Submitted 04/10/91

Constituent	mg/l (ppm)
Potassium	6
Sodium	1660
Calcium	25
Magnesium	7
Sulfate	112
Chloride	2300
Carbonate	0
Bicarbonate	309
Total Dissolved Solids @ 180° C	4050
Total Alkalinity as CaCO3	253
pH	8.2 s.u.
Nitrate plus Nitrite as N	0.07
Ammonia as N	3.0
Chemical Oxygen Demand	45
Total Organic Carbon	<2
Total Cyanide	<0.005
Metals:	
Arsenic	0.008
Barium	0.3
Cadmium	0.003
Chromium	<0.02
Iron	0.11
Lead	0.02
Manganese	0.02
Mercury	<0.001
Selenium	<0.005
Silver	<0.005

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FAX (406) 252-6069 • 1-800-873-5227

LABORATORY REPORT

TO: Damschen & Associates
ADDRESS: Curt Coover
P.O. Box 4817
Helena, MT 59604

LAB NO.: 91-12851
DATE: 04/25/91 da

WATER ANALYSIS

Unified Disposal District
Shop Well, Tap in Shop
Sampled 04/04/91 @ 5:00 p.m.
Submitted 04/10/91

Constituent	mg/l (ppm)
Potassium	2
Sodium	1100
Calcium	10
Magnesium	3
Sulfate	12
Chloride	1240
Carbonate	0
Bicarbonate	757
Total Dissolved Solids @ 180° C	2640
Total Alkalinity as CaCO3	620
pH	8.2 s.u.
Nitrate plus Nitrite as N	<0.05
Ammonia as N	2.0
Chemical Oxygen Demand	38
Total Organic Carbon	2
Total Cyanide	<0.005
Metals:	
Arsenic	<0.005
Barium	0.3
Cadmium	<0.001
Chromium	<0.02
Iron	0.06
Lead	<0.01
Manganese	<0.02
Mercury	<0.001
Selenium	<0.005
Silver	<0.005

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LABORATORY REPORT

TO: Damschen & Associates
ADDRESS: Curt Coover
P.O. Box 4817
Helena, MT 59604

LAB NO.: 91-12851 spi
DATE: 04/25/91 da

QUALITY ASSURANCE-SPIKED ANALYSIS

Unified Disposal District
Shop Well, Tap in Shop
Sampled 04/04/91 @ 5:00 p.m.
Submitted 04/10/91

Constituent	% Recovery	
Potassium	90	
Sodium	108	
Calcium	96	
Magnesium	99	
Sulfate	103	
Chloride	101	
Carbonate	N/A	
Bicarbonate	N/A	
Total Dissolved Solids @ 180° C	N/A	
Total Alkalinity as CaCO3	N/A	
pH	N/A	s.u.
Nitrate plus Nitrite as N	109	
Ammonia as N	96	
Chemical Oxygen Demand	92	
Total Organic Carbon	93	
Total Cyanide	82	
Metals:		
Arsenic	104	
Barium	103	
Cadmium	100	
Chromium	94	
Iron	90	
Lead	91	
Manganese	100	
Mercury	*	
Selenium	107	
Silver	87	

*Unable to spike. The sample contains an unknown interferent.

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LABORATORY REPORT

TO: Damschen & Associates
ADDRESS: Curt Coover
P.O. Box 4817
Helena, MT 59604

LAB NO.: 91-12852
DATE: 04/25/91 da

WATER ANALYSIS

Unified Disposal District
MW-1, North Side
Sampled 04/04/91 @ 7:00 p.m.
Submitted 04/10/91

Constituent	mg/l (ppm)
Potassium	4
Sodium	690
Calcium	5
Magnesium	2
Sulfate	714
Chloride	39
Carbonate	32
Bicarbonate	780
Total Dissolved Solids @ 180° C	1800
Total Alkalinity as CaCO3	693
pH	8.8 s.u.
Nitrate plus Nitrite as N	0.13
Ammonia as N	1.2
Chemical Oxygen Demand	17
Total Organic Carbon	2
Total Cyanide	<0.005
Metals:	
Arsenic	<0.005
Barium	<0.1
Cadmium	<0.001
Chromium	<0.02
Iron	4.08
Lead	<0.01
Manganese	<0.02
Mercury	<0.001
Selenium	<0.005
Silver	<0.005

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FAX (406) 252-6069 • 1-800-735-0277

LABORATORY REPORT

TO: Dames&Moo & Associates
ADDRESS: Curt Coeyer
P.O. Box 4817
Helena, MT 59604

LAB NO.: 91-12852
DATE: 04/25/91 da

WATER ANALYSIS

Unified Disposal District
MW-1, North Side
Sampled 04/04/91 @ 7:00 p.m.
Submitted 04/10/91

Constituent	mg/L (ppm)
Potassium	4
Sodium	890
Calcium	8
Magnesium	2
Sulfate	714
Chloride	39
Carbonate	32
Bicarbonate	780
Total Dissolved Solids @ 180° C	1800
Total Alkalinity as CaCO3	893
pH	8.8 s.u.
Nitrate plus Nitrite as N	0.13
Ammonia as N	1.2
Chemical Oxygen Demand	17
Total Organic Carbon	7
Total Cyanide	<0.005

Metals	
Arsenic	<0.005
Barium	<0.1
Cadmium	<0.001
Chromium	<0.02
Iron	4.08
Lead	<0.01
Manganese	<0.02
Mercury	<0.001
Selenium	<0.005
Silver	<0.005

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FAX (406) 252-6069 • 1-800-873-5227

LABORATORY REPORT

TO: Damschen & Associates
ADDRESS: Curt Coover
P.O. Box 4817
Helena, MT 59604

LAB NO.: 91-12850
DATE: 04/25/91 da

WATER ANALYSIS

PHASE I - Volatile Organic Constituents

Unified Disposal District
MW-2, South Side
Sampled 04/04/91 @ 4:00 p.m.
Submitted 04/10/91

Constituent	µg/l	Constituent	µg/l
Acetone	<10	Chloromethane	<1.0
Acrolein	13	Dibromomethane	<1.0
Acrylonitrile	<10	1,4-Dichloro-2-butene	<10
Benzene	<0.50	Dichlorodifluoromethane	<1.0
Bromochloromethane	<1.0	1,1-Dichloroethane	<1.0
Bromodichloromethane	<1.0	1,2-Dichloroethane	<0.50
cis-1,3-Dichloropropene	<1.0	2-Hexanone	<10
trans-1,3-Dichloropropene	<1.0	Iodomethane	<10
1,4-Difluorobenzene	<10	Methylene chloride	<1.0
Ethanol, mg/l	<10	4-Methyl-2-pentanone	<10
Ethylbenzene	<1.0	1,1-Dichloroethene	<0.50
Ethyl methacrylate	<10	trans-1,2-Dichloroethene	<1.0
4-Bromofluorobenzene	<10	Styrene	<1.0
Bromoform	<1.0	1,1,2,2-Tetrachloroethane	<1.0
Bromomethane	<1.0	Toluene	<1.0
2-Butanone (Methyl Ethyl Ketone)	<10	1,1,1-Trichloroethane	<0.50
		1,1,2-Trichloroethane	<1.0
Carbon disulfide	<10	Trichloroethene	<0.50
Carbon tetrachloride	<0.50	Trichlorofluoromethane	<1.0
Chlorobenzene	<1.0	1,2,3-Trichloropropane	<1.0
Dibromochloromethane	<1.0	Vinyl acetate	<10
Chloroethane	<1.0	Vinyl chloride	<0.50
2-Chloroethyl vinyl ether	<10	Xylenes	<1.0
Chloroform	<1.0		

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FAX (406) 252-6069 • 1-800-873-5227

LABORATORY REPORT

TO: Damschen & Associates
ADDRESS: Curt Coover
P.O. Box 4817
Helena, MT 59604

LAB NO.: 91-12850 dup
DATE: 04/25/91 da

QUALITY ASSURANCE-DUPLICATE ANALYSIS

PHASE I - Volatile Organic Constituents

Unified Disposal District
MW-2, South Side
Sampled 04/04/91 @ 4:00 p.m.
Submitted 04/10/91

Constituent	µg/l	Constituent	µg/l
Acetone	<10	Chloromethane	<1.0
Acrolein	<10	Dibromomethane	<1.0
Acrylonitrile	<10	1,4-Dichloro-2-butene	<10
Benzene	<0.50	Dichlorodifluoromethane	<1.0
Bromochloromethane	<1.0	1,1-Dichloroethane	<1.0
Bromodichloromethane	<1.0	1,2-Dichloroethane	<0.50
cis-1,3-Dichloropropene	<1.0	2-Hexanone	<10
trans-1,3-Dichloropropene	<1.0	Iodomethane	<10
1,4-Difluorobenzene	<10	Methylene chloride	<1.0
Ethanol, mg/l	<10	4-Methyl-2-pentanone	<10
Ethylbenzene	<1.0	1,1-Dichloroethene	<0.50
Ethyl methacrylate	<10	trans-1,2-Dichloroethene	<1.0
4-Bromofluorobenzene	<10	Styrene	<1.0
Bromoform	<1.0	1,1,2,2-Tetrachloroethane	<1.0
Bromomethane	<1.0	Toluene	<1.0
2-Butanone (Methyl Ethyl Ketone)	<10	1,1,1-Trichloroethane	<0.50
		1,1,2-Trichloroethane	<1.0
Carbon disulfide	<10	Trichloroethene	<0.50
Carbon tetrachloride	<0.50	Trichlorofluoromethane	<1.0
Chlorobenzene	<1.0	1,2,3-Trichloropropane	<1.0
Dibromochloromethane	<1.0	Vinyl acetate	<10
Chloroethane	<1.0	Vinyl chloride	<0.50
2-Chloroethyl vinyl ether	<10	Xylenes	<1.0
Chloroform	<1.0		

REMARKS: Acrolein was present in the first vial tested and absent in the second vial. The amount found in the first vial was only slightly above the detection limit and acrolein is very unstable.

ENERGY LABORATORIES, INC.
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FAX (406) 252-6069 • 1-800-873-5227

LABORATORY REPORT

TO: Damschen & Associates
ADDRESS: Curt Coover
P.O. Box 4817
Helena, MT 59604

LAB NO.: 91-12851
DATE: 04/25/91 da

WATER ANALYSIS

PHASE I - Volatile Organic Constituents

Unified Disposal District
Shop Well, Tap in Shop
Sampled 04/04/91 @ 5:00 p.m.
Submitted 04/10/91

Constituent	µg/l	Constituent	µg/l
Acetone	<10	Chloromethane	<1.0
Acrolein	<10	Dibromomethane	<1.0
Acrylonitrile	<10	1,4-Dichloro-2-butene	<10
Benzene	<0.50	Dichlorodifluoromethane	<1.0
Bromochloromethane	<1.0	1,1-Dichloroethane	<1.0
Bromodichloromethane	<1.0	1,2-Dichloroethane	<0.50
cis-1,3-Dichloropropene	<1.0	2-Hexanone	<10
trans-1,3-Dichloropropene	<1.0	Iodomethane	<10
1,4-Difluorobenzene	<10	Methylene chloride	<1.0
Ethanol, mg/l	<10	4-Methyl-2-pentanone	<10
Ethylbenzene	<1.0	1,1-Dichloroethene	<0.50
Ethyl methacrylate	<10	trans-1,2-Dichloroethene	<1.0
4-Bromofluorobenzene	<10	Styrene	<1.0
Bromoform	<1.0	1,1,2,2-Tetrachloroethane	<1.0
Bromomethane	<1.0	Toluene	<1.0
2-Butanone (Methyl Ethyl Ketone)	<10	1,1,1-Trichloroethane	<0.50
		1,1,2-Trichloroethane	<1.0
Carbon disulfide	<10	Trichloroethene	<0.50
Carbon tetrachloride	<0.50	Trichlorofluoromethane	<1.0
Chlorobenzene	<1.0	1,2,3-Trichloropropane	<1.0
Dibromochloromethane	<1.0	Vinyl acetate	<10
Chloroethane	<1.0	Vinyl chloride	<0.50
2-Chloroethyl vinyl ether	<10	Xylenes	<1.0
Chloroform	<1.0		

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FAX (406) 252-6069 • 1-800-735-0227

LABORATORY REPORT

TO: Damschen & Associates
ADDRESS: Court Cooper
P.O. Box 4817
Helena, MT 59604

LAB NO.: 91-12851
DATE: 04/25/91 da

WATER ANALYSIS

PHASE I - Volatile Organic Constituents

Unified Disposal District
Shop Well, Tap in Shop
Sampled 04/04/91 @ 8:00 p.m.
Submitted 04/10/91

Constituent	Amt	Constituent	Amt
Acetone	< 10	Chloromethane	< 1.0
Acrolein	< 10	Dibromomethane	< 1.0
Acrylonitrile	< 10	1,4-Dichloro-2-butene	< 10
Benzene	< 0.50	Dichlorodifluoromethane	< 1.0
Bromochloromethane	< 1.0	1,1-Dichloroethane	< 1.0
Bromodichloromethane	< 1.0	1,2-Dichloroethane	< 0.50
cis-1,3-Dichloropropene	< 1.0	2-Hexanone	< 10
trans-1,3-Dichloropropene	< 1.0	Iodomethane	< 10
1,4-Difluorobenzene	< 10	Methylene chloride	< 1.0
Ethanol, mg/l	< 10	4-Methyl-2-pentanone	< 10
Ethylbenzene	< 1.0	1,1-Dichloroethene	< 0.50
Ethyl methacrylate	< 10	trans-1,2-Dichloroethene	< 1.0
4-Bromofluorobenzene	< 10	Styrene	< 1.0
Bromoform	< 1.0	1,1,2,2-Tetrachloroethane	< 1.0
Bromomethane	< 1.0	Toluene	< 1.0
2-Butanone	< 10	1,1,1-Trichloroethane	< 0.50
(Methyl Ethyl Ketone)		1,1,2-Trichloroethane	< 1.0
Carbon disulfide	< 10	Trichloroethene	< 0.50
Carbon tetrachloride	< 0.50	Trichlorofluoromethane	< 1.0
Chlorobenzene	< 1.0	1,2,3-Trichloropropane	< 1.0
Dibromochloromethane	< 1.0	Vinyl acetate	< 10
Chloroethane	< 1.0	Vinyl chloride	< 0.50
2-Chloroethyl vinyl ether	< 10	Xylenes	< 1.0
Chloroform	< 1.0		

ENERGY LABORATORIES, INC.
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FAX (406) 252-6069 • 1-800-873-5227

LABORATORY REPORT

TO: Damschen & Associates
ADDRESS: Curt Coover
P.O. Box 4817
Helena, MT 59604

LAB NO.: 91-12852
DATE: 04/25/91 da

WATER ANALYSIS

PHASE I - Volatile Organic Constituents

Unified Disposal District
MW-1, North Side
Sampled 04/04/91 @ 7:00 p.m.
Submitted 04/10/91

Constituent	µg/l	Constituent	µg/l
Acetone	<10	Chloromethane	<1.0
Acrolein	<10	Dibromomethane	<1.0
Acrylonitrile	<10	1,4-Dichloro-2-butene	<10
Benzene	<0.50	Dichlorodifluoromethane	<1.0
Bromochloromethane	<1.0	1,1-Dichloroethane	<1.0
Bromodichloromethane	<1.0	1,2-Dichloroethane	<0.50
cis-1,3-Dichloropropene	<1.0	2-Hexanone	<10
trans-1,3-Dichloropropene	<1.0	Iodomethane	<10
1,4-Difluorobenzene	<10	Methylene chloride	<1.0
Ethanol, mg/l	<10	4-Methyl-2-pentanone	<10
Ethylbenzene	<1.0	1,1-Dichloroethene	<0.50
Ethyl methacrylate	<10	trans-1,2-Dichloroethene	<1.0
4-Bromofluorobenzene	<10	Styrene	<1.0
Bromoform	<1.0	1,1,2,2-Tetrachloroethane	<1.0
Bromomethane	<1.0	Toluene	<1.0
2-Butanone (Methyl Ethyl Ketone)	<10	1,1,1-Trichloroethane	<0.50
		1,1,2-Trichloroethane	<1.0
Carbon disulfide	<10	Trichloroethene	<0.50
Carbon tetrachloride	<0.50	Trichlorofluoromethane	<1.0
Chlorobenzene	<1.0	1,2,3-Trichloropropane	<1.0
Dibromochloromethane	<1.0	Vinyl acetate	<10
Chloroethane	<1.0	Vinyl chloride	<0.50
2-Chloroethyl vinyl ether	<10	Xylenes	<1.0
Chloroform	<1.0		

ENERGY LABORATORIES, INC.
P.O. BOX 30916 • 1107 SOUTH BROADWAY • BILLINGS, MT 59107-0916 • PHONE (406) 252-6325
FAX (406) 252-6069 • 1-800-873-5227

LABORATORY REPORT

TO: Damschen & Associates
ADDRESS: Curt Coover
P.O. Box 4817
Helena, MT 59604

LAB NO.: 91-12850 -52
DATE: 04/25/91 da

WATER VOLATILE SURROGATE RECOVERY

10 µg/l Surrogate Standard Spike

	------% recovery------		
SAMPLE NO.	S1 (TOL)#	S2 (BFB)#	S3 (DCE)#
91-12850	86	108	101
91-12850 dup	98	107	114
91-12851	109	102	103
91-12852	80	119	95

	QC LIMITS, % Recovery
S1 (TOL) = Toluene-d8	80-120
S2 (BFB) = Bromofluorobenzene	80-120
S3 (DCE) = 1,2-Dichloroethane-d4	80-120

#Column to be used to flag recovery values with an asterisk.

*Values outside of contract required QC limits.

ENERGY LABORATORIES, INC.
P.O. BOX 30916 • 1107 SOUTH BROADWAY • BILLINGS, MT 59107-0916 • PHONE (406) 252-6325
FAX (406) 252-6069 • 1-800-873-5227

LABORATORY REPORT

TO: Damschen & Associates
ADDRESS: Curt Coover
P.O. Box 4817
Helena, MT 59604

LAB NO.: 91-12852
DATE: 04/25/91 da

QUALITY ASSURANCE-SPIKED ANALYSIS

Lab No. 91-12852 was spiked with the following constituents with these results

Constituent	Spike Amount, µg/l	P (%)	Range for P (%)
1,1-Dichloroethene	5.0	95	60-140
Benzene	5.0	112	60-140
Trichloroethene	5.0	104	60-140
Toluene	5.0	111	60-140
Chlorobenzene	5.0	90	60-140

P = Percent recovery measured.

89-33 B

UNIFIED DISPOSAL DISTRICT

SAMPLERS: (Signature)

STAT. NO.	DATE	TIME	COMP.	GRAB	STATION LOCATION	NO. OF CONTAINERS	UNFILTERED	FILTERED	VOC				REMARKS
MW-2	4-4	4pm.		X	MW-2 - SOUTH SIDE	4	X	X	X				RCRA SUBTITLED PHASE I PARAMETERS - SEE TABLE I
SHOP	4-4	5pm.		X	SHOP WELL - TAP IN SHOP	3	X		X				
MW-1	4-4	7pm.		X	MW-1 - NORTH SIDE	4	X	X	X				

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
	4-8 11am				
Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Relinquished by: (Signature)	Date/Time	Received for Laboratory by: (Signature)	Date/Time	Remarks	
		Kevin Stevenson	4/10/91 11:59		

Split Samples: [ ] Accepted [ ] Declined

Signature

MONTANA DEPARTMENT OF HEALTH
AND ENVIRONMENTAL SCIENCES
Solid & Hazardous Waste Bureau
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Rec'd 10/30/91